UNCLASSIFIED

AD NUMBER

ADC034022

CLASSIFICATION CHANGES

TO: unclassified

FROM: confidential

LIMITATION CHANGES

TO:

Approved for public release, distribution unlimited

FROM:

Distribution limited to U.S. Gov't. agencies only; Test and Evaluation; 12 Apr 84. Other requests must be referred to the Commanding Officer, NORDA, NSTL Station, MS 39529.

AUTHORITY

ONR ltr., Ser 93/160, 10 Mar 1999; SAME

THIS PAGE IS UNCLASSIFIED

AD-E001573

CONFIDENTIAL

(3)

NORDA Report 36
Book 2 of 3

AD C034022

The Acoustic Model Evaluation Committee (AMEC) Reports

Volume III, Appendices A-D

Evaluation of the RAYMODE X Propagation Loss Model (U)

Prepared by

Richard B. Lauer, NORDA
Numerical Modeling Division

Including

The Physics of RAYMODE X (U)

by Roy Deavenport, NUSC
New London, Connecticut

September 1982

Distribution limited to U.S. Government agencies only. Other requests for this document must be referred to the Commanding Officer, Naval Ocean Research and Development Activity, NSTL Station, Mississippi 39529

T&E 12 APR 1984

Classified by OPNAVINST 5513.5 (3)

Declassify on OADR

Naval Ocean Research and Development Activity
NSTL Station, Mississippi 39529

84 04 06 511

CONFIDENTIAL

Appendix IIIA. Accuracy Assessment of RAYMODE X Compared to SUDS Experimental Data (U)

SUDS I (U)

Environment (U)

(C) All environmental measurements come from station 1 of the SUDS 1 measurements. Three sound speed profiles, given in Figures IIIA-1-3, represent average conditions during three measurement periods. These sound speed profiles, in accordance with Martin (1982), will be referred to as profiles A, E, and B. Profile A has a surface duct to a depth of 68 meters (m) overlying a sound channel with axis at 900 m. Profile E is an average profile with a 20 m surface duct, a subsurface channel with an axis at 200 m and a deep sound channel with axis at 900 m. Profile B has a surface duct to a depth of 79 m and a deep sound channel with axis at 900 m.

(C) The source used pulsed energy, and bottom bounce arrivals were temporally filtered out. The effective bottom loss for model input should therefore be ∞ dB (actually, a bottom loss of 50 dB was entered for all grazing angles).

Test cases (U)

(C) The 12 test cases selected from SUDS I experimental data for use in model evaluation are given in the table below. In this table, R_{min} is the minimum range at which data is found, R_{max} is the maximum range and SSP denotes sound speed profile.

(C) Both source and receiver are in the surface duct for Cases I, III, IX and XI. Source and receiver are in a cross-duct geometry in Cases II, IV, V, VII, X and XII. Both source and receiver are below the duct for Cases VI and VIII. The SUDS experimental data for the 12 test cases are plotted in Figures IIIA-4-15.

Accuracy Assessment Results (U)

(U) Accuracy assessment procedures were followed as outlined in section 1.1 and described in detail in section 5 of Volume I of this series. The following figures are given for each case: (1) RAYMODE X results obtained using the

CASE	SOURCE DEPTH (m)	RECEIVER DEPTH (m)	FREQUENCY (kHz)	R_{min} (km)	R_{max} (km)	NO. OF POINTS	SSP	WIND SPEED (kn)
I	45	17	0.4	2.0	24.5	925	A	11
II	45	112	0.4	2.0	17.4	625	A	11
III	42	43	1.0	2.0	24.4	959	A	11
IV	42	112	2.0	2.0	24.8	818	A	11
V	41	6	1.5	0.4	24.6	796	E	4
VI	41	59	1.5	0.4	24.8	811	E	4
VII	41	6	2.5	0.4	24.8	868	E	4
VIII	41	59	2.5	0.4	24.8	866	E	4
IX	45	17	3.5	0.1	35.3	1311	B	6
X	45	112	3.5	0.1	35.8	918	B	6
XI	42	17	5.0	0.1	35.5	1421	B	6
XII	42	112	5.0	0.1	33.8	959	B	6

coherent phase addition option, (2) smoothed RAYMODE X coherent results obtained by applying a running average with a 2 km window, (3) the smoothed RAYMODE X coherent result subtracted from the SUDS experimental data, (4) RAYMODE X results obtained using the incoherent (i.e., rms) phase addition option, and (5) the RAYMODE X incoherent results subtracted from the SUDS experimental data. These plots for the 12 test cases are given in Figure IIIA-16 through IIIA-75.

(C) The means and standard deviations of the difference between the SUDS experimental data and the RAYMODE X smoothed coherent and incoherent outputs are given in Table IIIA-1. For Case I, the RAYMODE X coherent and incoherent outputs are totally different than the SUDS data--the RAYMODE transmission loss curve is concave downward, the SUDS curve concave upward. In Case II the curves are qualitatively and quantitatively similar. Case I, we recall, has an in-layer source/receiver geometry whereas Case II has cross-layer geometry. One would expect greater loss for the cross-layer Case II than for the in-layer Case I. For the SUDS data this is true; the separation between the in-layer and cross-layer curves was found to be about 15 dB. By contrast, the RAYMODE curves differ by a few dB (the cross-layer case having less loss) to 9 km. From 9 to 15 km, the cross-duct case shows substantially less loss (by as much as 8 dB). After 15 km, the models are in basic agreement. Case III is another in-layer source/receiver geometry and the difference between the SUDS curve and the RAYMODE curve (unless otherwise stated, remarks apply to coherent and incoherent results alike) simply increases with range. Case IV is a cross-layer case in which agreement between SUDS and RAYMODE is excellent to 20 km. From 20 to 24 km a 7 dB bias is seen in the difference curve due to RAYMODE continuing a trend to higher loss while SUDS assumes a constant loss in this range interval. Case V is characterized by cross-layer source/receiver geometry. The SUDS/RAYMODE agreement is poor, the discrepancy increasing with range. Case VI is the first below-layer source/receiver geometry and basic agreement is achieved over the full range extent of 24 km. This agreement extends to include the degree of fine scale fluctuations and the presence of a 6 km interference pattern. Case VII is a cross-layer case for which SUDS and RAYMODE results are completely lacking in agreement. Here the SUDS data shows increasing propagation loss to about 10 km, from which point the loss decreases. RAYMODE, on the other hand, shows increasing loss with range to 24 km. Both SUDS and RAYMODE show strong but disagreeing interference patterns. For the below-layer geometry of Case VIII, the curves show a constant 18 dB offset to 6 km, beyond which SUDS and RAYMODE have strong interference patterns with quite similar periods. Beyond 10 km, differences are due to phasing of the interference patterns: they are almost out of phase by π radians. The region between 6 and 10 km is the transition region--at the start the curves are in phase but are of very different level and change to agreeing in level but being out of phase. Case IX, a case of in-layer geometry shows qualitative difference between the RAYMODE model and SUDS experiment results. SUDS shows less loss and an interference pattern with a period ranging between 3 and 4 km compared to RAYMODE coherent for which interference nulls (beyond initial Lloyd Mirror effects) are seen at 6 and 26 km. These broad nulls are filled-in, in the RAYMODE incoherent output leading to somewhat better (although still seriously differing qualitatively and quantitatively) agreement with SUDS data. For the cross-duct geometry of Case X substantial agreement is found to 7 km, from which point disagreement grows: beyond 16 km, the disagreement levels off at a devastating 20 dB. Aside from the portion of the data where clipping is obvious, the upper envelope of the RAYMODE curve is at or below the lower envelope of the SUDS data. For in-layer Case XI, the

most serious discrepancy is with regard to interference patterns. For RAYMODE a weak interference pattern (peak to null values of 3 dB) with a period of about 7 km is seen; for SUDS strong interference (peak to null values of 15-25 dB) with periods between 2 and 3 km are found. The RAYMODE curve rides at or above the peaks of the SUDS curve. Case XII, having cross-layer geometry, is another example of qualitative and quantitative dissimilarity; the slopes of the loss curves are in utter disagreement. The relatively low mean values in Table IIIA-1 for this case are due to canceling negative and positive effects--here, the standard deviation is the important indicator.

(C) Let us now turn to the Figure of Merit (FOM) analysis. FOM versus detection range is tabulated for SUDS data and both RAYMODE X coherent and incoherent results at 5 dB increments for the twelve cases in Tables IIIA-2-13. For Case I, the RAYMODE results are grossly pessimistic compared to SUDS detection ranges. SUDS detection ranges are four times as great as RAYMODE's for FOM = 75 dB. This factor decreases until at FOM = 95 dB, SUDS detection range results are twice those of RAYMODE. For Case II, RAYMODE predictions are pessimistic compared to SUDS detection ranges. At low figures of merit, RAYMODE detection ranges are 65% of SUDS; this percentage is 80% at FOM = 95 dB. Case III is a case of grossly pessimistic results for RAYMODE as compared to SUDS. SUDS predicts detection coverage over the full extent of the data (24.5 km) for FOM $\geq$ 80 dB; RAYMODE predicts coverage to 6 km at FOM = 80 dB; at FOM = 100 dB, RAYMODE predicts coverage to 24 km, but with some zonal effects. Case IV detection coverage is twice as great for SUDS as is predicted by RAYMODE. For Case V, SUDS detection ranges are again twice as great as those predicted by RAYMODE. Case VI is the first case for which RAYMODE predictions are optimistic, although only slightly so. For this case, SUDS and RAYMODE are in close agreement, generally differing by 1 dB or less for FOM $\leq$ 90 dB. This is also true for Case VII. Here, however, RAYMODE predictions are pessimistic by a factor of two for FOM $\geq$ 95 dB. Case VIII is the only case where RAYMODE is optimistic in detection range by a factor as large as two. It should be noted that the SUDS detection ranges are quite small through FOM = 100 dB (5.5 km). In Case IX, RAYMODE gives much less detection coverage than SUDS data indicate should be achieved. Here, a great difference is found between the RAYMODE coherent and incoherent results, particularly for FOM = 85 dB. Case X is another case in which the detection ranges for SUDS data are usually about twice those of RAYMODE X predictions. In Case XI, good agreement in detection range is generally achieved (within 2 dB) although significant differences are found between RAYMODE coherent and incoherent results. Finally, in Case XII, RAYMODE is slightly optimistic for FOM $\leq$ 95 dB with both SUDS and RAYMODE predicting fairly short detection ranges. For FOM > 95 dB, SUDS results show somewhat greater detection ranges than do RAYMODE predictions (i.e., RAYMODE pessimistic with respect to SUDS).

(C) The following are concluded from the above: (1) In terms of decibel differences between SUDS and RAYMODE data, only Cases II, IV, and VI show fair agreement. Case II and IV are cases of cross-layer source/receiver geometry at 400 and 1000 Hz, respectively. Cases of cross-layer geometry at higher frequencies showed basic qualitative and quantitative disagreement between SUDS data and RAYMODE X results. All cases of both source and receiver in the layer showed lack of agreement between SUDS and RAYMODE. Of the two below-layer cases, VI showed good agreement between SUDS and RAYMODE, but VIII did not. (2) The figure of merit analysis shows RAYMODE predictions of detection range to be <u>strongly pessimistic</u> compared to SUDS results in Cases I, II, III, IV, V, IX and X (not uncommonly by a factor of 2). Only in Case VIII were RAYMODE detection ranges much longer (by a factor of 2) than those of SUDS. No clear trend

emerges with regard to source/receiver geometry. (3) It would appear from comparison with SUDS data that the surface duct module of RAYMODE X is deficient. This is further borne out in section 3, The Physics of the RAYMODE X Model, by R. Deavenport.

References (U)

Martin, R. L., et al. (1982). Summary of Range-Independent Environmental Acoustic Propagation Data Sets (U). Vol. IA, The Acoustic Model Evaluation Committee (AMEC) Reports, NORDA Report 34, Naval Ocean Research and Development Activity, NSTL Station, Miss. (CONFIDENTIAL)

(U) Table IIIA-1. Means (μ) and Standard Deviations of Differences Obtained by Subtracting (1) Smoothed[1] RAYMODE X Coherent Output and (2) RAYMODE X Incoherent Output from SUDS Experimental Data (in dB).

Case	RAYMODE X Smoothed Coherent		RAYMODE X Incoherent	
	μ	σ	μ	σ
I	-12.5	12.9	-10.7	11.9
II	-2.2	3.9	-2.2	3.7
III	-10.1	9.3	-10.4	9.9
IV	-0.9	3.3	-1.3	3.5
V	-10.3	10.1	-8.7	9.4
VI	-0.4	3.7	0.6	3.9
VII	-4.1	10.4	-3.6	10.5
VIII	4.7	7.5	5.0	8.5
IX	-11.7	10.1	-5.7	6.0
X	-13.4	8.8	-10.2	7.9
XI	-8.9	6.9	-6.6	6.4
XII	-3.7	10.1	-1.6	9.5

1. RAYMODE X coherent output was smoothed by application of a running average with a 2 kilometer window.

CONFIDENTIAL

(C) Table IIIA-2. Detection Range in km as a Function of Figure of Merit (FOM) in dB for SUDS I Data and RAYMODE X Model Results.
CASE I:
(Station 1, Run 3, Source Depth = 45 m, Receiver Depth = 17 m, Frequency = 400 Hz)

DATA SET	FOM	R_c [1]	Range > R_c
SUDS	70	12.0	
RAYMODE X Coherent	70	3.0	
RAYMODE X Incoherent	70	3.0	
SUDS	75	15.5	
RAYMODE X Coherent	75	3.5	
RAYMODE X Incoherent	75	4.0	
SUDS	80	17.0	
RAYMODE X Coherent	80	5.0	
RAYMODE X Incoherent	80	5.5	
SUDS	85	18.5	
RAYMODE X Coherent	85	7.0	
RAYMODE X Incoherent	85	7.5	
SUDS	90	19.5	
RAYMODE X Coherent	90	8.5	
RAYMODE X Incoherent	90	9	
SUDS	95	20.5	ZDC[2] 70%, 20.5-24 km
RAYMODE X Coherent	95	12	
RAYMODE X Incoherent	95	12	
SUDS	100	>24	
RAYMODE X Coherent	100	12.5	100% coverage 21-22 km
RAYMODE X Incoherent	100	12	100% coverage 20-24
SUDS	105	>24	
RAYMODE X Coherent	105	14	100% coverage 14.5-16.5 km, 17.5-25 km
RAYMODE X Incoherent	105	13.5	100% coverage 14->24 km

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval over which detection is possible.

(C) Table IIIA-3. Detection Range in km as a Function of Figure of Merit (FOM) in dB for SUDS I Data and RAYMODE X Model Results.
CASE II:
(Station 1, Run 3, Source Depth = 45 m, Receiver Depth = 112 m, Frequency = 400 Hz)

DATA SET	FOM	R_c [1]	Range > R_c
SUDS	75		ZDC[2] 90%, 1.5-6.5 km
RAYMODE X Coherent	75	4.5	
RAYMODE X Incoherent	75	4	
SUDS	80	7.0	
RAYMODE X Coherent	80	5.5	
RAYMODE X Incoherent	80	5	
SUDS	85	7.5	ZDC 15%, 7.5-13 km
RAYMODE X Coherent	85	7	
RAYMODE X Incoherent	85	7	
SUDS	90	10.5	ZDC 70%, 10.5-14.5 km
RAYMODE X Coherent	90	8.5	
RAYMODE X Incoherent	90	8	
SUDS	95	16.5	
RAYMODE X Coherent	95	14	
RAYMODE X Incoherent	95	14	
SUDS	100	>16.5	
RAYMODE X Coherent	100	14.5	
RAYMODE X Incoherent	100	14.5	
SUDS	105	>16.5	
RAYMODE X Coherent	105	15	
RAYMODE X Incoherent	105	15.5	ZDC 70%, 15.5-16.5 km
SUDS	110	>16.5	
RAYMODE X Coherent	110	15.5	
RAYMODE X Incoherent	110	>16.5	

1. R_c = Range to which detection coverage is continuous.
2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval over which detection is possible.

CONFIDENTIAL

(C) Table IIIA-4. Detection Range in km as a Function of Figure of Merit (FOM) in dB for SUDS I Data and RAYMODE X Model Results.
CASE III:
(Station 1, Run 4, Source Depth = 42 m, Receiver Depth = 43 m, Frequency = 1 Hz)

DATA SET	FOM	R_c [1]	Range > R_c
SUDS	75	7.0	100% coverage, 7.5-17.5 km with one dropout at 15 km
RAYMODE X Coherent	75	4.0	
RAYMODE X Incoherent	75	4.0	
SUDS	80	21.5	ZDC[2] 60%, 21.5-24.5 km
RAYMODE X Coherent	80	6.5	
RAYMODE X Incoherent	80	6	
SUDS	85	>24.5	
RAYMODE X Coherent	85	9	ZDC 60%, 10.5-11.5 km
RAYMODE X Incoherent	85	7	100% coverage 7.5-9 km
SUDS	90	>24.5	
RAYMODE X Coherent	90	9.5	100% coverage 10-12 km, 12.5-14 km
RAYMODE X Incoherent	90	9.5	100% coverage 10-12 km, 12.5-13 km, 13-13.5 km
SUDS	95	>24.5	
RAYMODE X Coherent	95	14	100% coverage 15.5-16.5 km, 18-18.5
RAYMODE X Incoherent	95	14	
SUDS	100	>24.5	
RAYMODE X Coherent	100	14.5	ZDC 75%, 15-24 km
RAYMODE X Incoherent	100	14.5	ZDC 95%, 14.5-22 km
SUDS	105	>24.5	
RAYMODE X Coherent	105	>24	
RAYMODE X Incoherent	105	24	

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval over which detection is possible.

(C) Table IIIA-5. Detection Range in km as a Function of Figure of Merit (FOM) in dB for SUDS I Data and RAYMODE X Model Results.
CASE IV:
(Station 1, Run 4, Source Depth = 42 m, Receiver Depth = 112 m, Frequency = 1 kHz)

DATA SET	FOM	R_c[1]	Range > R_c
SUDS	75		ZDC[2] 90%, 2.5-5 km
RAYMODE X Coherent	75	3.0	
RAYMODE X Incoherent	75	3.3	
SUDS	80	5.5	ZDC 80%, 5.5-6.5 km
RAYMODE X Coherent	80	3.5	100% coverage 4-5 km
RAYMODE X Incoherent	80	10.5	
SUDS	85	7.0	
RAYMODE X Coherent	85	7.5	
RAYMODE X Incoherent	85	7.5	
SUDS	90	7.0	ZDC 5%, 7-15 km
RAYMODE X Coherent	90	8.0	
RAYMODE X Incoherent	90	8.0	
SUDS	95	8.0	ZDC 40%, 8-16.5 km
RAYMODE X Coherent	95	8.5	100% coverage 9-11 km ZDC[2] 30%, 12-15.5 km
RAYMODE X Incoherent	95	9.0	100% coverage 9.5-11 km
SUDS	100	8.5	ZDC 80%, 8.5-16.5 km, ZDC 50%, 16.5-18.5 km; ZDC 20%, 18.5-24.5 km
RAYMODE X Coherent	100	16.0	100% coverage 17-18 km, and 16.5 km
RAYMODE X Incoherent	100	13.5	ZDC 45%, 14-17.5 km
SUDS	105	17.0	ZDC 95%, 17-24.5 km
RAYMODE X Coherent	105	18.0	100% coverage 19.5-20.5 km
RAYMODE X Incoherent	105	18.5	
SUDS	110	>24.5	
RAYMODE X Coherent	110	18.5	100% coverage 19-21 km, 21.5-23 km
RAYMODE X Incoherent	110	19.0	ZDC 70%, 19.5-25.5 km

1. R_c = Range to which detection coverage is continuous.
2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval over which detection is possible.

CONFIDENTIAL

(C) Table IIIA-6. Detection Range in km as a Function of Figure of Merit (FOM) in dB for SUDS I Data and RAYMODE X Model Results.
CASE V:
(Station 1, Run 1, Source Depth = 41 m, Receiver Depth = 6 m, Frequency = 1.5 kHz)

DATA SET	FOM	R_c[1]	Range > R_c
SUDS	70		100% coverage, 0.5-4 km
RAYMODE X Coherent	70	2.0	
RAYMODE X Incoherent	70	2.0	
SUDS	75		100% coverage, 0.5-5 km; ZDC[2] 50%, 5-6 km
RAYMODE X Coherent	75	3.5	
RAYMODE X Incoherent	75	4.0	
SUDS	80		100% coverage, 0.5-8 km and 19.5-22 km
RAYMODE X Coherent	80	4.0	
RAYMODE X Incoherent	80	4.0	
SUDS	85	9.0	ZDC 35%, 9-11.5 km; ZDC 90%, 11.5-18 km; 100% coverage, 19-22.5 km
RAYMODE X Coherent	85	4.0	100% coverage 5-5.5 km
RAYMODE X Incoherent	85	5.0	
SUDS	90	9.0	100% coverage, 9.5-11, 11.5-18, 18.5-23; ZDC 50%, 23-24.5 km
RAYMODE X Coherent	90	4.0	ZDC 60%, 5-9 km
RAYMODE X Incoherent	90	5.0	100% coverage 6-7 km, 7.5-8.5 km
SUDS	95	9.0	ZDC 98%, 9-24.5 km
RAYMODE X Coherent	95	4.0	ZDC 70%, 5.5-11 km
RAYMODE X Incoherent	95	5.5	100% coverage 5.5-8.5 km, 9-10 km
SUDS	100	>24.5	
RAYMODE X Coherent	100	4.0	ZDC 70%, 5-17 km
RAYMODE X Incoherent	100	10.5	ZDC 75%, 11-16.5 km
SUDS	105	>24.5	
RAYMODE X Coherent	105	7.0	ZDC 65% 7-19 km
RAYMODE X Incoherent	105	17.0	ZDC 70% 17-23 km
SUDS	110	>24.5	
RAYMODE X Coherent	110	10.5	ZDC 80% 11->24 km
RAYMODE X Incoherent	110	19.5	ZDC 75%, 19.5->24 km

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval over which detection is possible.

(C) Table IIIA-7. Detection Range in km as a Function of Figure of Merit (FOM) in dB for SUDS I Data and RAYMODE X Model Results.
CASE VI:
(Station 1, Run 1, Source Depth = 41 m, Receiver Depth = 59 m, Frequency = 1.5 kHz)

DATA SET	FOM	R_c[1]	Range > R_c
SUDS	65		ZDC[2] 50%, 0.5-3 km
RAYMODE X Coherent	65	1.5	
RAYMODE X Incoherent	65	2.0	
SUDS	70		ZDC 70%, 0.5-3.5 km
RAYMODE X Coherent	70	2.5	100% coverage 3-4 km
RAYMODE X Incoherent	70	3.5	
SUDS	75		ZDC 85%, 0.5-3.5 km
RAYMODE X Coherent	75	2.5	100% coverage 3-5 km
RAYMODE X Incoherent	75	5.0	
SUDS	80	5.0	100% coverage 7-7.5 km
RAYMODE X Coherent	80	5.0	
RAYMODE X Incoherent	80	6.0	
SUDS	85	5.0	100% coverage, 6.5-8 km
RAYMODE X Coherent	85	5.0	100% coverage 6-6.5 and 7-9 km
RAYMODE X Incoherent	85	8.0	
SUDS	90	5.0	ZDC 85%, 5-11 km; ZDC 85%, 11.5-12.5 km; ZDC 30%, 14-16.5 km
RAYMODE X Coherent	90	10.5	
RAYMODE X Incoherent	90	10.5	
SUDS	95	11.0	ZDC 85%, 11-18 km; ZDC 85%, 20-22 km
RAYMODE X Coherent	95	11.0	100% coverage 13-15.5 km
RAYMODE X Incoherent	95	15.0	ZDC 65%, 13-22 km
SUDS	100	11.5	ZDC 95%, 11.5-18 km; ZDC 10%, 18-20.5 km; ZDC 90%, 20-22.5 km; ZDC 20%, 22.5-25 km
RAYMODE X Coherent	100	11.5	100% coverage 12-16.5 km, 19.5-22 km
RAYMODE X Incoherent	100	22.0	
SUDS	105	13.0	ZDC 95%, 13-24 km
RAYMODE X Coherent	105	11.5	100% coverage 12-18 km; 18.5-24.5 km
RAYMODE X Incoherent	105	>24	

1. R_c = Range to which detection coverage is continuous.
2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval over which detection is possible.

CONFIDENTIAL

(C) Table IIIA-8. Detection Range in km as a Function of Figure of Merit (FOM) in dB for SUDS I Data and RAYMODE X Model Results.
CASE VII:
(Station 1, Run 2, Source Depth = 41 m, Receiver Depth = 6 m, Frequency = 2.5 kHz)

DATA SET	FOM	R_c[1]	Range > R_c
SUDS	65		ZDC[2] 10%, 0-1 km
RAYMODE X Coherent	65	2.5	
RAYMODE X Incoherent	65	2.0	
SUDS	70		ZDC 60%, 0-1 km
RAYMODE X Coherent	70	3.0	
RAYMODE X Incoherent	70	3.0	
SUDS	75		ZDC 50%, 0-2 km
RAYMODE X Coherent	75	4.0	
RAYMODE X Incoherent	75	4.0	
SUDS	80		ZDC 70%, 0-4 km; 100% coverage, 21-22 km
RAYMODE X Coherent	80	4.0	
RAYMODE X Incoherent	80	4.0	
SUDS	85	1.0	ZDC 95%, 1-4 km; 100% coverage 17.5-18.5 and 20-23 km
RAYMODE X Coherent	85	4.0	ZDC 65%, 4.5-7 km
RAYMODE X Incoherent	85	5.5	
SUDS	90	4.0	ZDC 10%, 4-11 km; ZDC 90%, 15.5-23.5 km
RAYMODE X Coherent	90	5.0	100% coverage 5-7.5 km
RAYMODE X Incoherent	90	7.5	
SUDS	95	6.0	ZDC 80%, 6-17 km; ZDC 90%, 17-24 km
RAYMODE X Coherent	95	8.0	ZDC 70%, 8-10.5 km
RAYMODE X Incoherent	95	8.0	100% coverage 9-11 km
SUDS	100	7.0	ZDC 95%, 7-24.5 km
RAYMODE X Coherent	100	8.0	100% coverage 9-11.5 km; ZDC 70%, 13-15.5 km
RAYMODE X Incoherent	100	11.5	100% coverage 13-14.5 km
SUDS	105	>24.5	
RAYMODE X Coherent	105	12.0	ZDC 65% 12-23 km
RAYMODE X Incoherent	105	16.0	100% coverage 17-19 km

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval over which detection is possible.

(C) Table IIIA-9. Detection Range in km as a Function of Figure of Merit (FOM) in dB for SUDS I Data and RAYMODE X Model Results.
CASE VIII:
(Station 1, Run 2, Source Depth = 41 m, Receiver Depth = 59 m, Frequency = 2.5 kHz)

DATA SET	FOM	R_c[1]	Range > R_c
SUDS	70		ZDC[2] 15%, 0-1 km
RAYMODE X Coherent	70	2.5	
RAYMODE X Incoherent	70	3.0	
SUDS	75		ZDC 20%, 0-1 km
RAYMODE X Coherent	75	3.5	100% coverage 4.5-5.5 km
RAYMODE X Incoherent	75	5.0	
SUDS	80		ZDC 50%, 0-2 km
RAYMODE X Coherent	80	5.5	
RAYMODE X Incoherent	80	5.5	
SUDS	85		ZDC 60%, 0-3 km
RAYMODE X Coherent	85	6.0	
RAYMODE X Incoherent	85	7.0	
SUDS	90		ZDC 80%, 0-4 km
RAYMODE X Coherent	90	6.0	100% coverage 7-8 km, 10-11 km
RAYMODE X Incoherent	90	10.0	
SUDS	95	4.0	ZDC 50%, 4-5 km; 1/2 km coverage at 8 and 22 km
RAYMODE X Coherent	95	6.0	ZDC 60% 6.5-14.5 km
RAYMODE X Incoherent	95	11.0	
SUDS	100	5.0	ZDC 60%, 5-8.5 km; ZDC 50%, 11-18 km; ZDC 30%, 20.5-23 km
RAYMODE X Coherent	100	9.0	ZDC 70% 9.5-19 km
RAYMODE X Incoherent	100	15.0	
SUDS	105	6.0	ZDC 90%, 6-8.5 km; ZDC 20%, 8.5-11 km; ZDC 90%, 11-18.5 km; ZDC 75%, 20-23.5 km
RAYMODE X Coherent	105	12.5	ZDC 75% 13-30 km
RAYMODE X Incoherent	105	19.5	
SUDS	110	6.0	ZDC 95%, 6-18.5 km; ZDC 50%, 18.5-20 km; ZDC 95%, 20-24 km
RAYMODE X Coherent	110	>24.0	
RAYMODE X Incoherent	110	>24.0	

1. R_c = Range to which detection coverage is continuous.
2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval over which detection is possible.

(C) Table IIIA-10. Detection Range in km as a Function of Figure of Merit (FOM) in dB for SUDS I Data and RAYMODE X Model Results.
CASE IX:
(Station 1, Run 5, Source Depth = 45 m, Receiver Depth = 17 m, Frequency = 3.5 kHz)

DATA SET	FOM	R_c [1]	Range > R_c
SUDS	55		ZDC[2] 90%, 0-8.5 km; ZDC 50%, 11-12.5 km
RAYMODE X Coherent	65	2.0	coverage at 2 and 3 km
RAYMODE X Incoherent	65	2.5	
SUDS	70	9.0	ZDC 90%, 9.5-12.5 km; ZDC 5%, 14-17 km
RAYMODE X Coherent	70	3.5	
RAYMODE X Incoherent	70	3.5	
SUDS	75	9.0	ZDC 50%, 9-10 km; ZDC 90%, 10-13 km; ZDC 80%, 13-20 km
RAYMODE X Coherent	75	4.0	
RAYMODE X Incoherent	75	6.0	
SUDS	80	9.0	ZDC 90%, 9-21 km; ZDC 30%, 21-23.5 km; 100% coverage 23.5-27.5 km
RAYMODE X Coherent	80	5.0	100% coverage 14.5-20.5 km
RAYMODE X Incoherent	80	8.5	
SUDS	85	9.0	ZDC 90%, 9-32 km
RAYMODE X Coherent	85	5.5	
RAYMODE X Incoherent	85	22.5	
SUDS	90	23.0	ZDC 90%, 23-32 km; ZDC 10%, 32-36 km
RAYMODE X Coherent	90	6.5	100% coverage 10-23 km
RAYMODE X Incoherent	90	30.0	
SUDS	95	23.0	ZDC 95%, 23-32.5 km; ZDC 50%, 32.5-36 km
RAYMODE X Coherent	95	24.0	100% coverage 30.5->36 km
RAYMODE X Incoherent	95	>36	
SUDS	100	36.0	
RAYMODE X Coherent	100	25.0	100% coverage, 29->36 km
RAYMODE X Incoherent	100	>36	

1. R_c = Range to which detection coverage is continuous.
2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval over which detection is possible.

(C) Table IIIA-11. Detection Range in km as a Function of Figure of Merit (FOM) in dB for SUDS I Data and RAYMODE X Model Results.
CASE X:
(Station 1, Run 5, Source Depth = 45 m, Receiver Depth = 112 m, Frequency = 3.5 kHz)

DATA SET	FOM	R_c [1]	Range > R_c
SUDS	70		ZDC[2] 98%, 0-2.5 km; ZDC 15%, 2.5-4 km
RAYMODE X Coherent	70	3.0	
RAYMODE X Incoherent	70	3.0	
SUDS	75	2.5	ZDC 30%, 2.5-6 km
RAYMODE X Coherent	75	3.0	
RAYMODE X Incoherent	75	3.5	
SUDS	80	2.5	ZDC 60%, 4-6.5 km; ZDC 15%, 6.5-9 km
RAYMODE X Coherent	80	4.0	
RAYMODE X Incoherent	80	4.0	100% coverage 5-5.5 km
SUDS	85	4.0	ZDC 85%, 4-6.5; ZDC 30%, 6.5-10.5 km
RAYMODE X Coherent	85	6.5	
RAYMODE X Incoherent	35	6.5	
SUDS	90	7.0	ZDC 60%, 7-12.5 km; ZDC ?%, 12.5-17 km (data between 12 and 23 km is clipped)
RAYMODE X Coherent	90	8.0	
RAYMODE X Incoherent	90	8.5	
SUDS	95	10.5	ZDC 90%, 10.5-12.5 km; ZDC ?%, 12.5-21 km (data between 12 & 23 km is clipped); ZDC 10%, 23-25 km
RAYMODE X Coherent	95	9.5	
RAYMODE X Incoherent	95	10.0	
SUDS	100	?	Data between 12 & 23 km is clipped; 100% coverage to >12 km; ZDC 30%, 23-32.5 km
RAYMODE X Coherent	100	10.0	
RAYMODE X Incoherent	100	10.5	
SUDS	100	?	Data between 12 & 23 km is clipped; 100% coverage to >12 km; ZDC 50%, 23-32.5 km
RAYMODE X Coherent	105	10.0	ZDC 45%, 11-13 km
RAYMODE X Incoherent	105	14.0	
SUDS	110	?	Data between 12 & 23 km is clipped; 100% coverage to >12 km; ZDC 70%, 23-33.5 km
RAYMODE X Coherent	110	11.0	ZDC 65% 11.5-16 km
RAYMODE X Incoherent	110	13.5	ZDC 90% 14-19 km
SUDS	115	?	Data between 12 & 23 km is clipped; 100% coverage to >12 km; ZDC 90%, 23-34.5 km
RAYMODE X Coherent	115	13.5	ZDC 90%, 14-22 km
RAYMODE X Incoherent	115	17.0	ZDC 80% 17.5-25.5 km

1. R_c = Range to which detection coverage is continuous.
2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval over which detection is possible.

(C) Table IIIA-12. Detection Range in km as a Function of Figure of Merit (FOM) in dB for SUDS I Data and RAYMODE X Model Results.
CASE XI:
(Station 1, Run 6, Source Depth = 42 m, Receiver Depth = 17 m, Frequency = 5 kHz)

DATA SET	FOM	R_c [1]	Range > R_c
SUDS	70		ZDC[2] 50%, 0-2 km
RAYMODE X Coherent	70	2.5	100% coverage 3-5 km
RAYMODE X Incoherent	70	3.5	100% coverage 3.5-4.5 km
SUDS	75		ZDC 60%, 0-2 km; ZDC 15%, 2-4 km; ZDC 60%, 5.5-6.5 km
RAYMODE X Coherent	75	2.5	100% coverage 3-6 km
RAYMODE X Incoherent	75	5.0	
SUDS	80	1.5	ZDC 80%, 1.5-5 km; ZDC 60%, 5-8.5 km
RAYMODE X Coherent	90	13.0	
RAYMODE X Incoherent	80	7.5	
SUDS	85	1.5	ZDC 90%, 1.5-7 km; ZDC 70%, 7-13.5 km; ZDC 15%, 13.5-19 km
RAYMODE X Coherent	85	14.5	100% coverage 21-20.5 km
RAYMODE X Incoherent	85	14.0	
SUDS	90	4.5	ZDC 85%, 4.5-13 km; ZDC 50%, 13-19 km
RAYMODE X Coherent	90	22.0	100% coverage 23.5-28 km
RAYMODE X Incoherent	90	21.0	
SUDS	95	5.0	ZDC 90%, 5-19 km; ZDC 60%, 19.5-27.5 km; ZDC 15%, 27.5-32 km
RAYMODE X Coherent	95	>36	
RAYMODE X Incoherent	95	>36	

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval over which detection is possible.

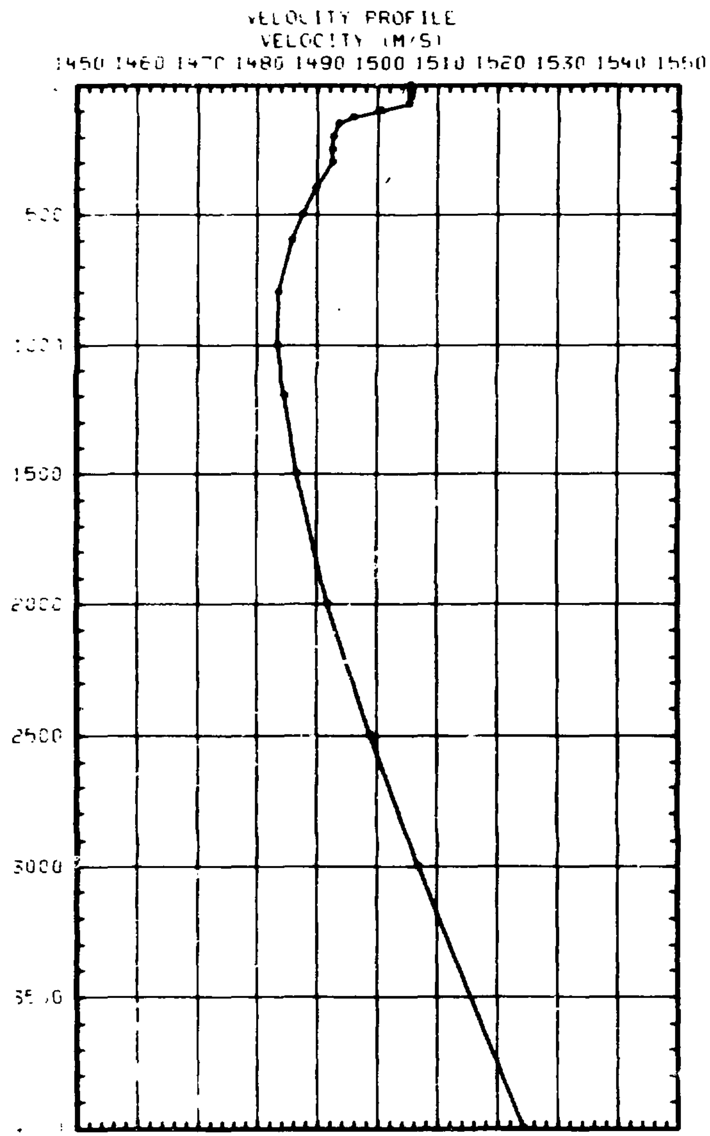
CONFIDENTIAL

(C) Table IIIA-13. Detection Range in km as a Function of Figure of Merit (FOM) in dB for SUDS I Data and RAYMODE X Model Results.
CASE XII:
(Station 1, Run 6, Source Depth = 42 m, Receiver Depth = 11 m, Frequency = 5 kHz)

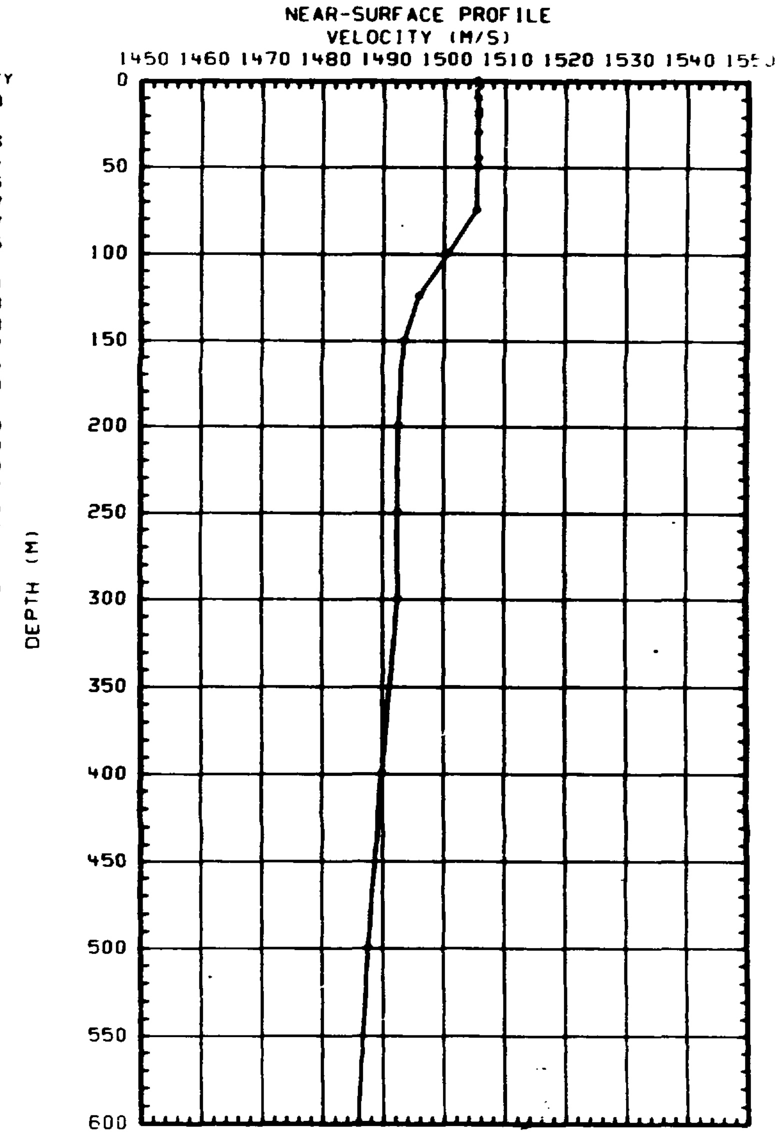
DATA SET	FOM	R_c[1]	Range > R_c
SUDS	70	0.5	ZDC[2] 50%, 0.5-1.5 km
RAYMODE X Coherent	70	2.3	
RAYMODE X Incoherent	70	2.5	
SUDS	75	2.5	ZDC 50%, 0.5-2 km
RAYMODE X Coherent	75	3.0	
RAYMODE X Incoherent	75	3.5	
SUDS	80	1.0	ZDC 50%, 1-2 km; ZDC 15%, 2-3.5 km
RAYMODE X Coherent	80	4.0	
RAYMODE X Incoherent	80	4.0	
SUDS	85	1.0	ZDC 90%, 1-3 km; ZDC 30%, 3-4 km
RAYMODE X Coherent	85	6.5	
RAYMODE X Incoherent	85	6.0	
SUDS	90	2.5	ZDC 30%, 2.5-5.5 km
RAYMODE X Coherent	90	7.5	
RAYMODE X Incoherent	90	7.5	
SUDS	95	3.5	ZDC 30%, 3.5-7 km
RAYMODE X Coherent	95	9.0	
RAYMODE X Incoherent	95	9.5	
SUDS	100	4.0	ZDC ?%, 4-14 km (data is clipped at high loss end)
RAYMODE X Coherent	100	9.5	
RAYMODE X Incoherent	100	9.5	
SUDS	105	5.0	ZDC ?%, 5-16.5 km (data is clipped at high loss end)
RAYMODE X Coherent	105	11.5	
RAYMODE X Incoherent	105	11.5	
SUDS	110	7.0	ZDC ?%, 7-25 km (data is clipped at high loss end)
RAYMODE X Coherent	110	11.5	ZDC 40%, 12-15 km
RAYMODE X Incoherent	110	11.5	ZDC 45%, 12.5-15 km
SUDS	115	?	ZDC ?%, to 23 km; (data is clipped at high loss end); ZDC 35%,23-25 km; ZDC 10%, 25-29 km
RAYMODE X Coherent	115	12	ZDC 35%, 12.5-17.5 km
RAYMODE X Incoherent	115	14	ZDC 40%, 14.5-19.5 km
SUDS	120	?	ZDC ?% to 23 Km (data is clipped at high loss end); ZDC 40%, 23 29 km
RAYMODE X Coherent	120	13.5	ZDC 70%, 14-21 km
RAYMODE X Incoherent	120	16	ZDC 70%, 16.5 23.5 km

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval over which detection is possible.



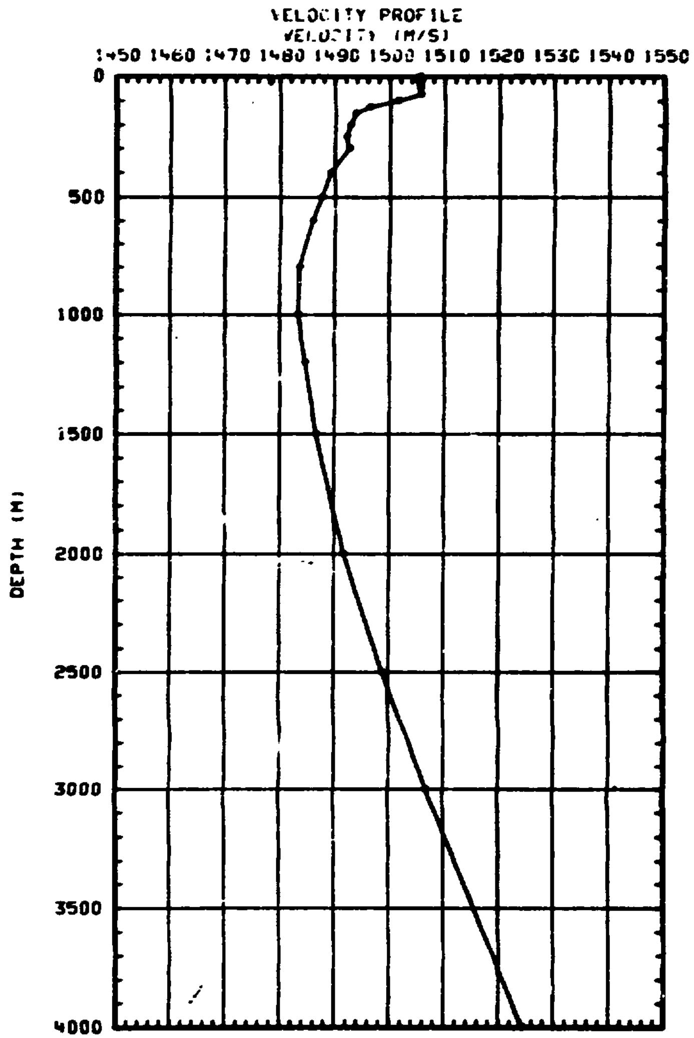
DEPTH	VELOCITY
0.0	1505.29
10.0	1505.41
17.4	1505.43
20.0	1505.44
30.0	1505.46
45.0	1505.47
50.0	1505.47
75.0	1505.25
100.0	1500.61
125.0	1495.80
150.0	1493.38
200.0	1492.48
250.0	1492.37
300.0	1492.45
400.0	1489.79
500.0	1487.54
600.0	1485.79
800.0	1483.59
1000.0	1483.39
1200.0	1484.57
1500.0	1486.66
2000.0	1491.70
2500.0	1498.90
3000.0	1506.90
4000.0	1524.30



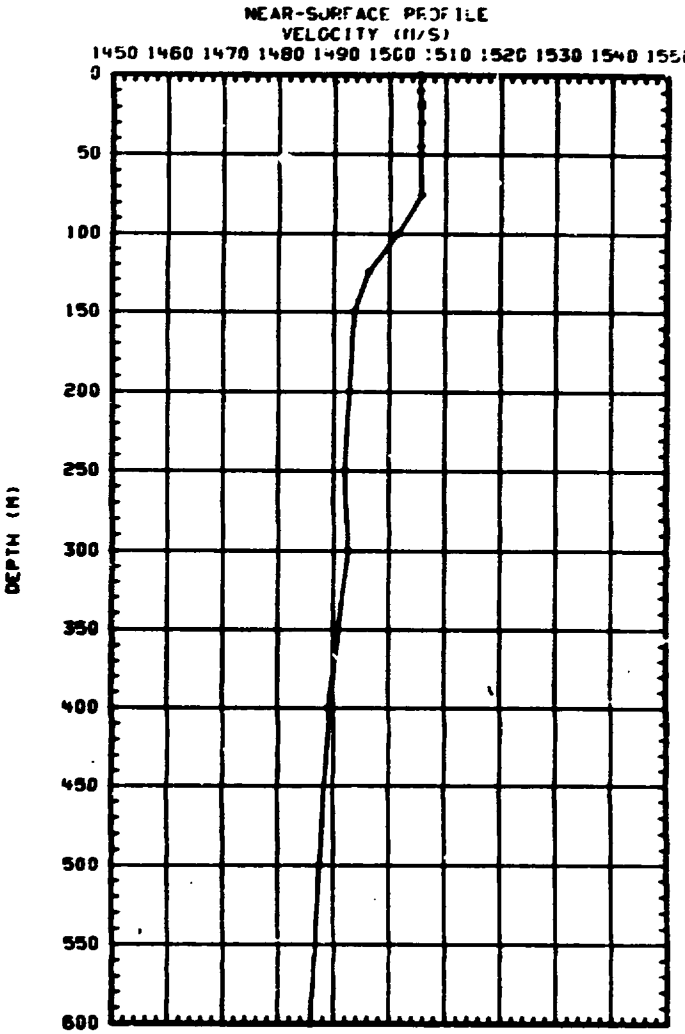
CONFIDENTIAL

(U) Figure IIIA-1. SUDS Sound Speed Profile A

+ NUSC 8-S-81NS TDSUSEA954005312 SN 5 TIME 12:00:00 DATE 02/26/80 Page 1



DEPTH	VELOCITY
0.0	1505.35
10.0	1505.38
17.4	1505.42
20.0	1505.44
30.0	1505.40
45.0	1505.50
50.0	1505.50
75.0	1505.61
100.0	1501.37
125.0	1498.22
150.0	1493.66
200.0	1492.73
250.0	1492.03
300.0	1492.50
400.0	1489.20
500.0	1487.54
600.0	1485.79
800.0	1483.50
1000.0	1483.30
1200.0	1484.57
1500.0	1486.00
2000.0	1491.70
2500.0	1498.80
3000.0	1506.00
4000.0	1524.30

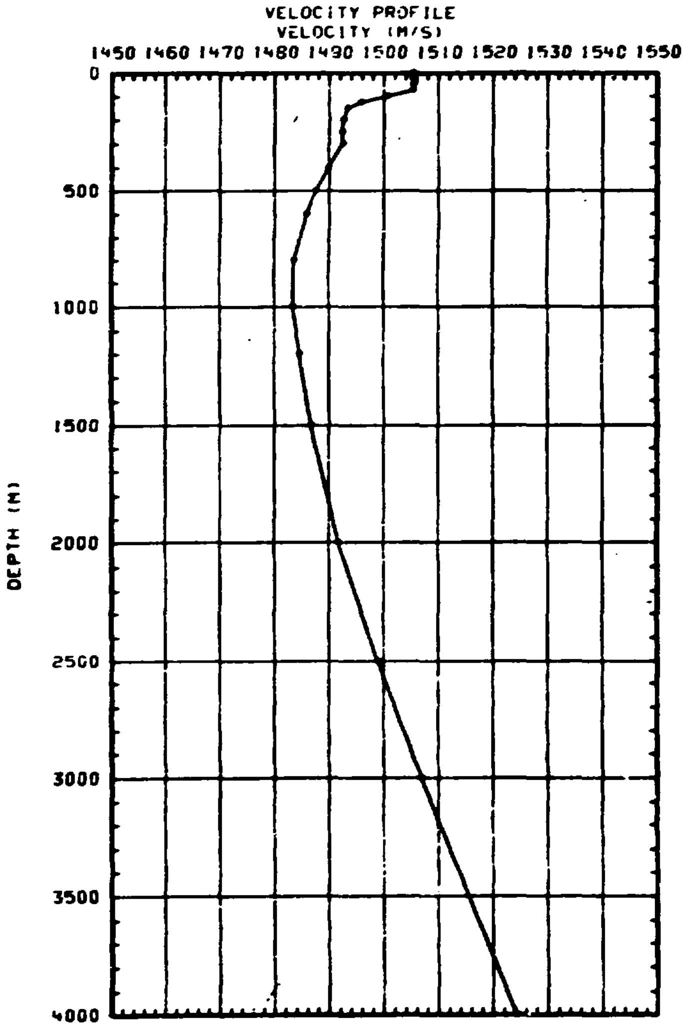


SUDS --- F=3.5KH,ZS=45M,ZR=17M

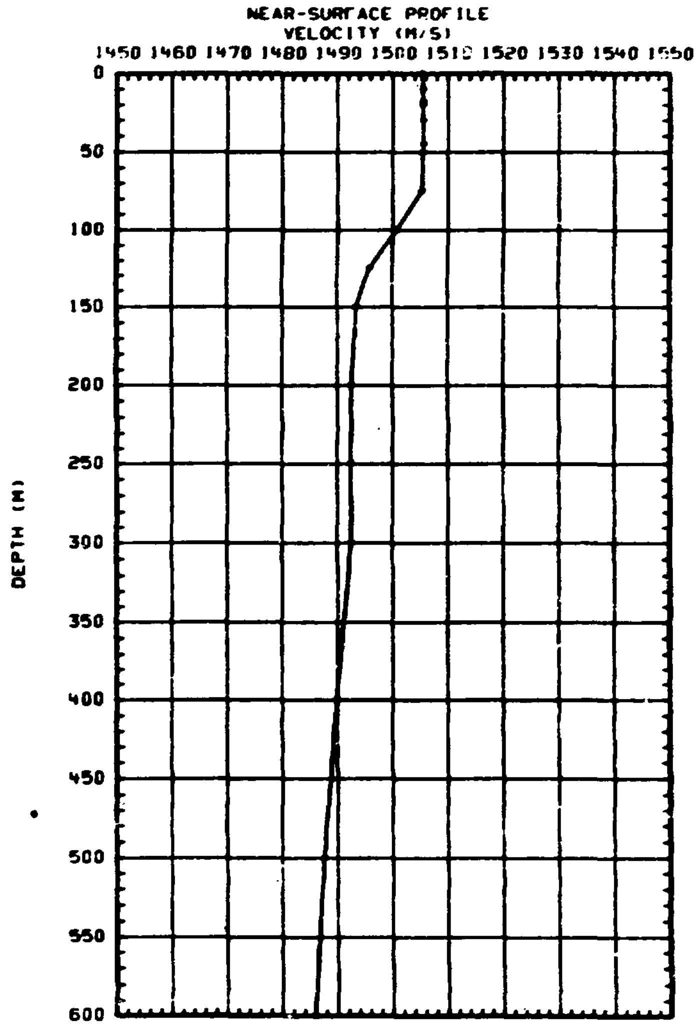
CONFIDENTIAL

(U) Figure IIIA-2. SUDS Sound Speed Profile E

NUSC B-S-BINS TDSUSSA054B0S312 BN 5 TIME 12:16:02 DATE 02/20/00 Page 1



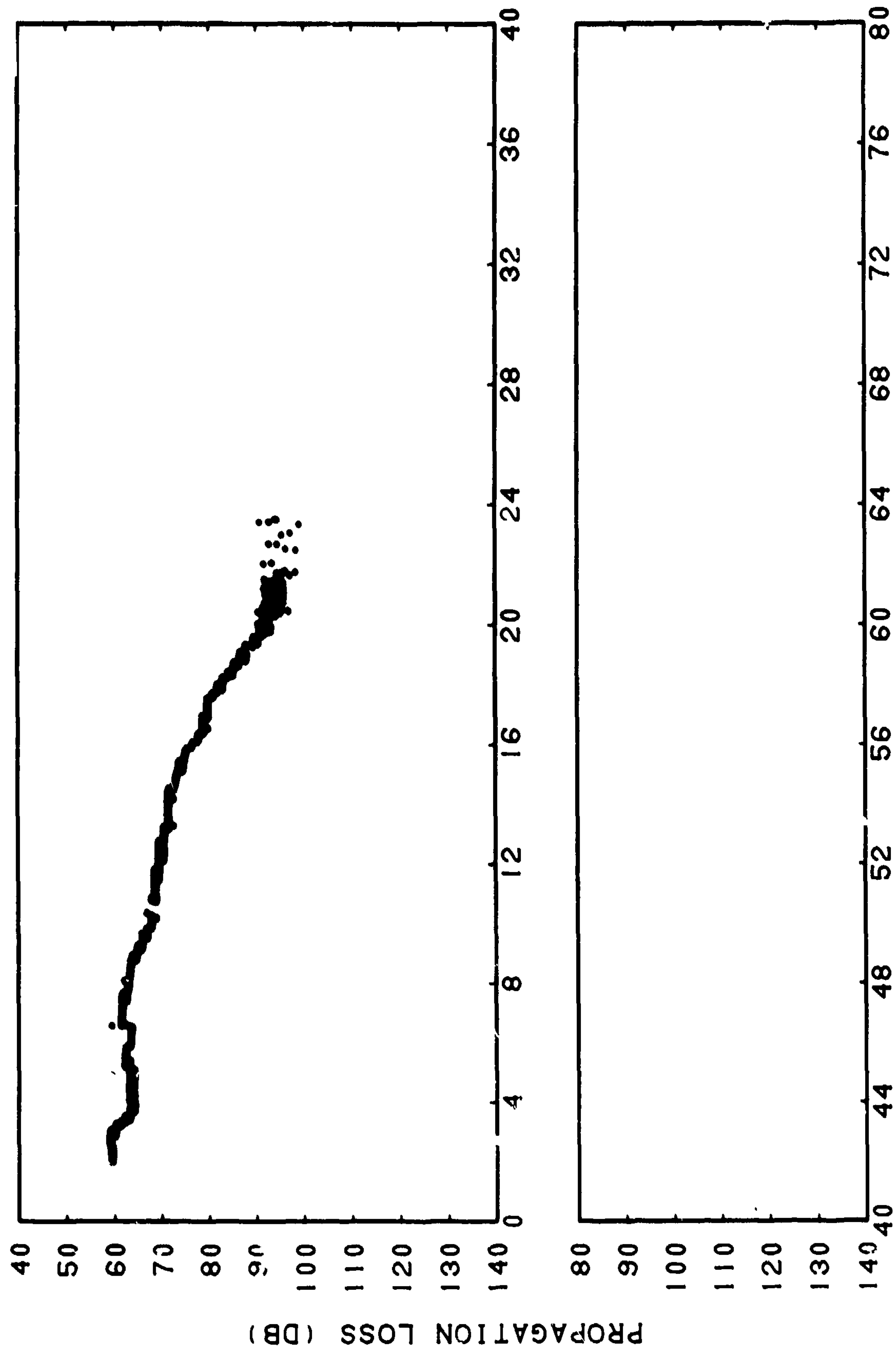
DEPTH	VELOCITY
0.0	1505.29
10.0	1505.41
17.4	1505.43
20.0	1505.44
30.0	1505.46
45.0	1505.47
50.0	1505.47
75.0	1505.25
100.0	1500.61
125.0	1495.80
150.0	1493.30
200.0	1492.48
250.0	1492.37
300.0	1492.45
400.0	1489.79
500.0	1487.54
600.0	1485.70
800.0	1483.50
1000.0	1483.39
1200.0	1484.57
1500.0	1486.86
2000.0	1491.70
2500.0	1498.90
3000.0	1506.90
4000.0	1524.30



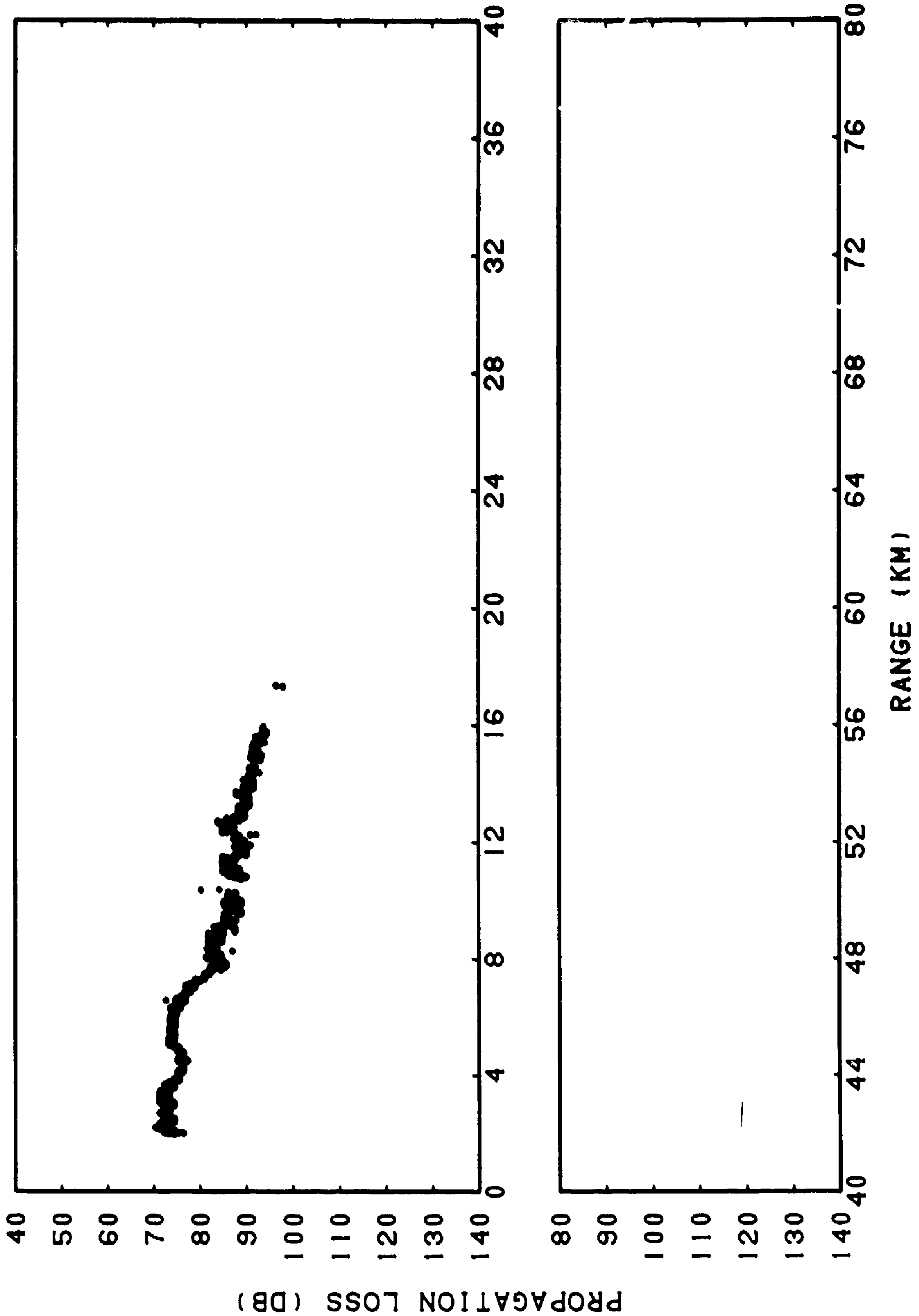
SUDS --- F=0.4KH,ZS=45M,ZR=17M

CONFIDENTIAL

(U) Figure IIIA-3. SUDS Sound Speed Profile B

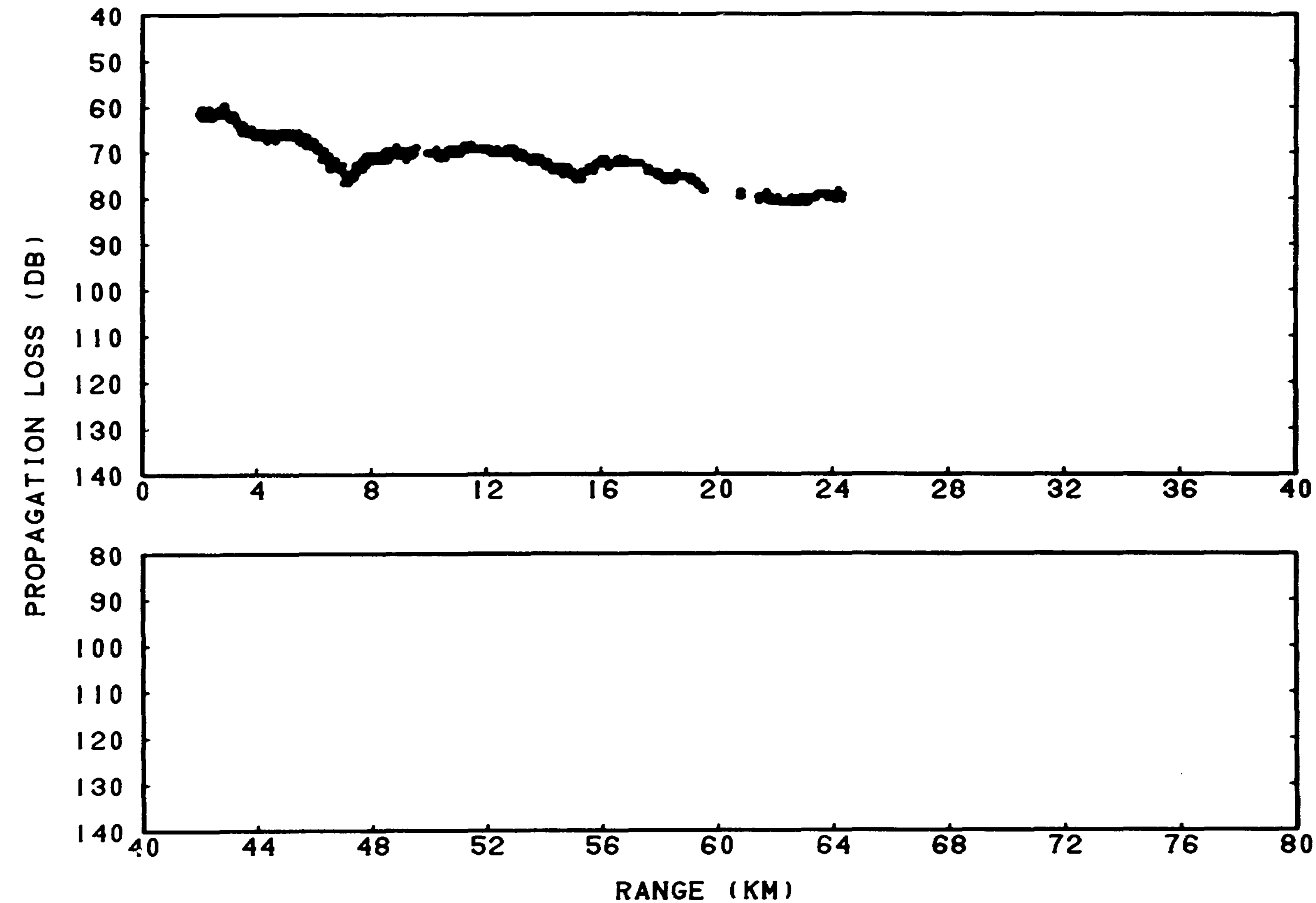


(C) Figure IIIA-4. SUDS Data, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters



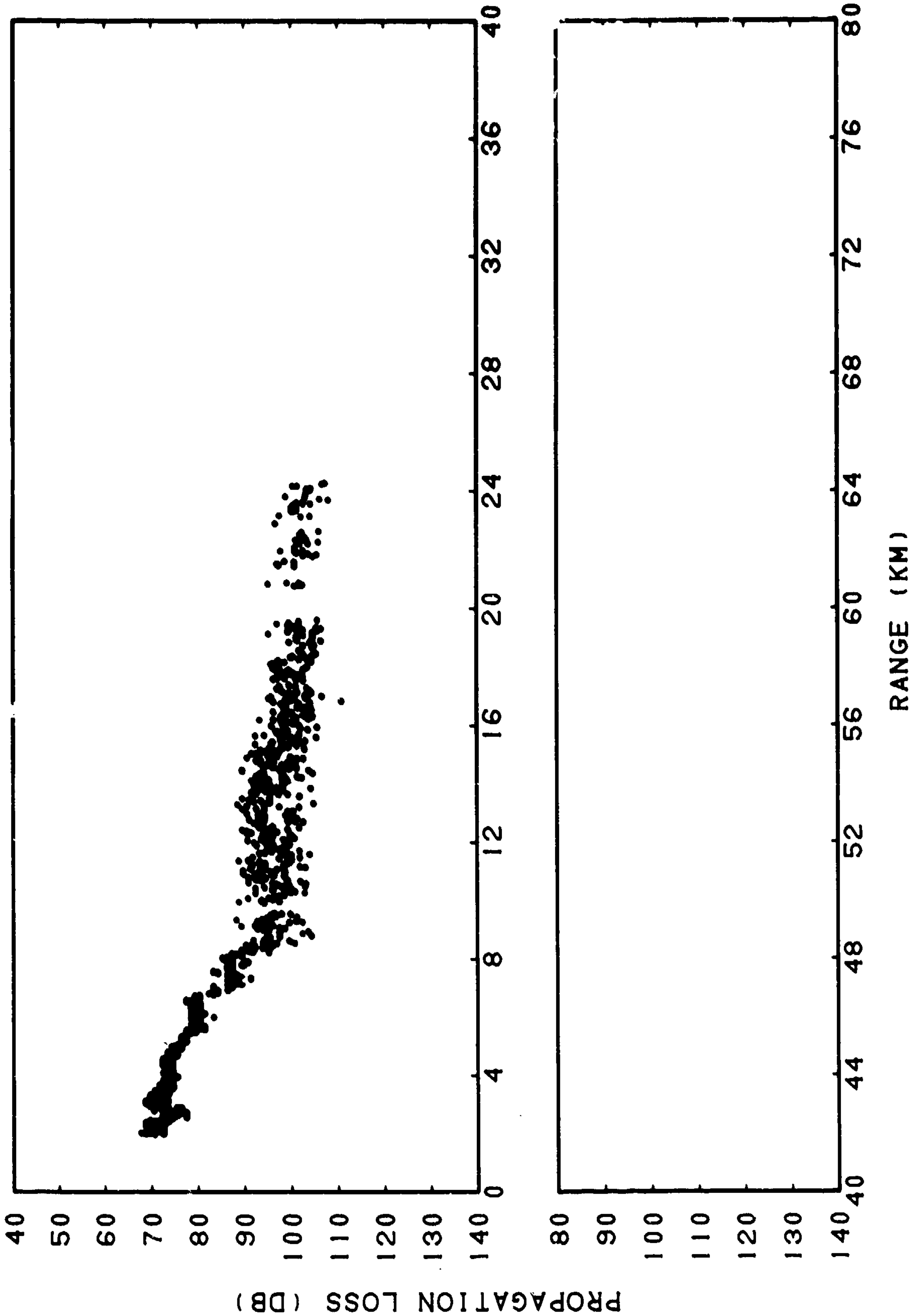
CONFIDENTIAL

(C) Figure IIIA-5. SUDS Data, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters



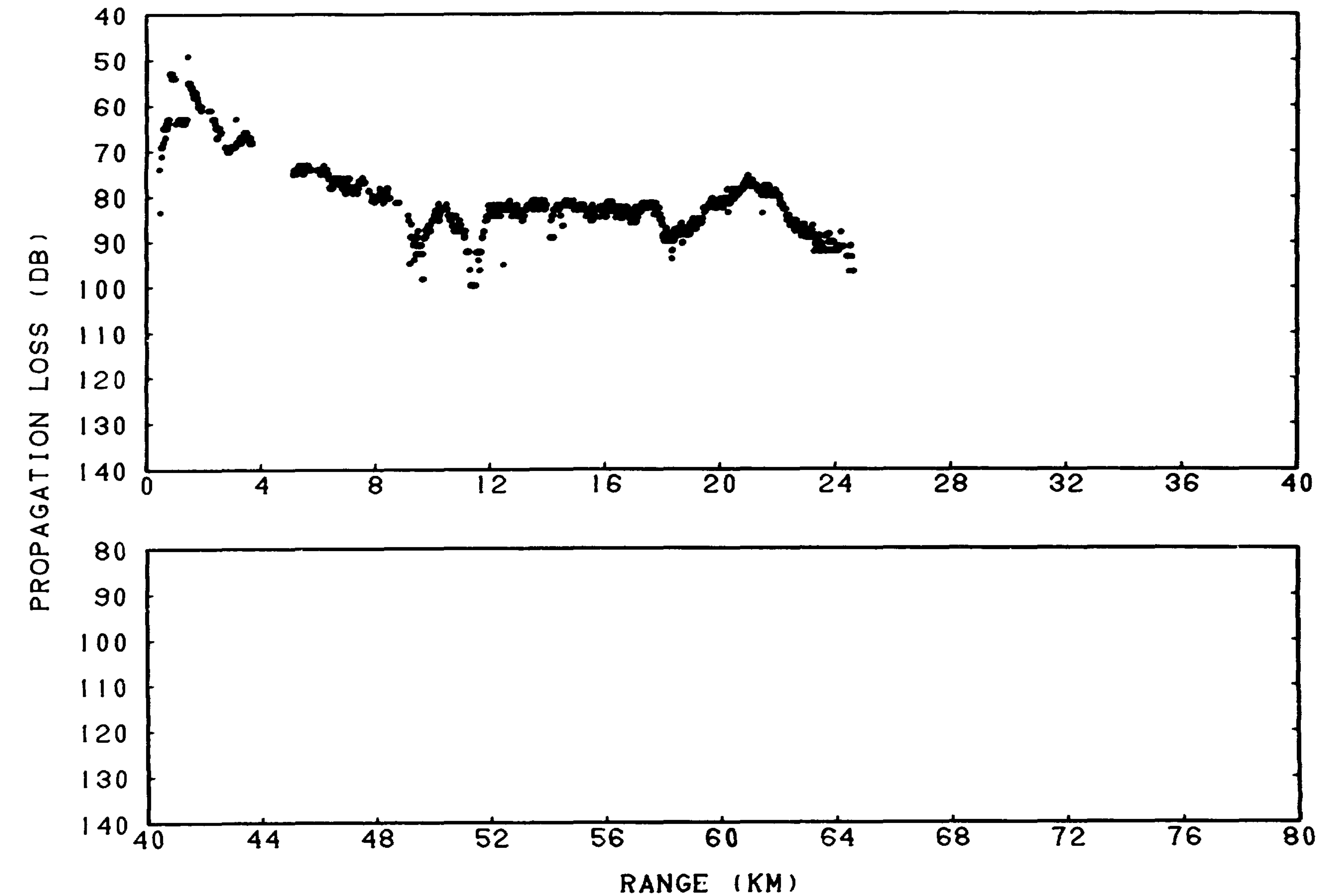
CONFIDENTIAL

(C) Figure IIIA-6. SUDS Data, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 43 Meters



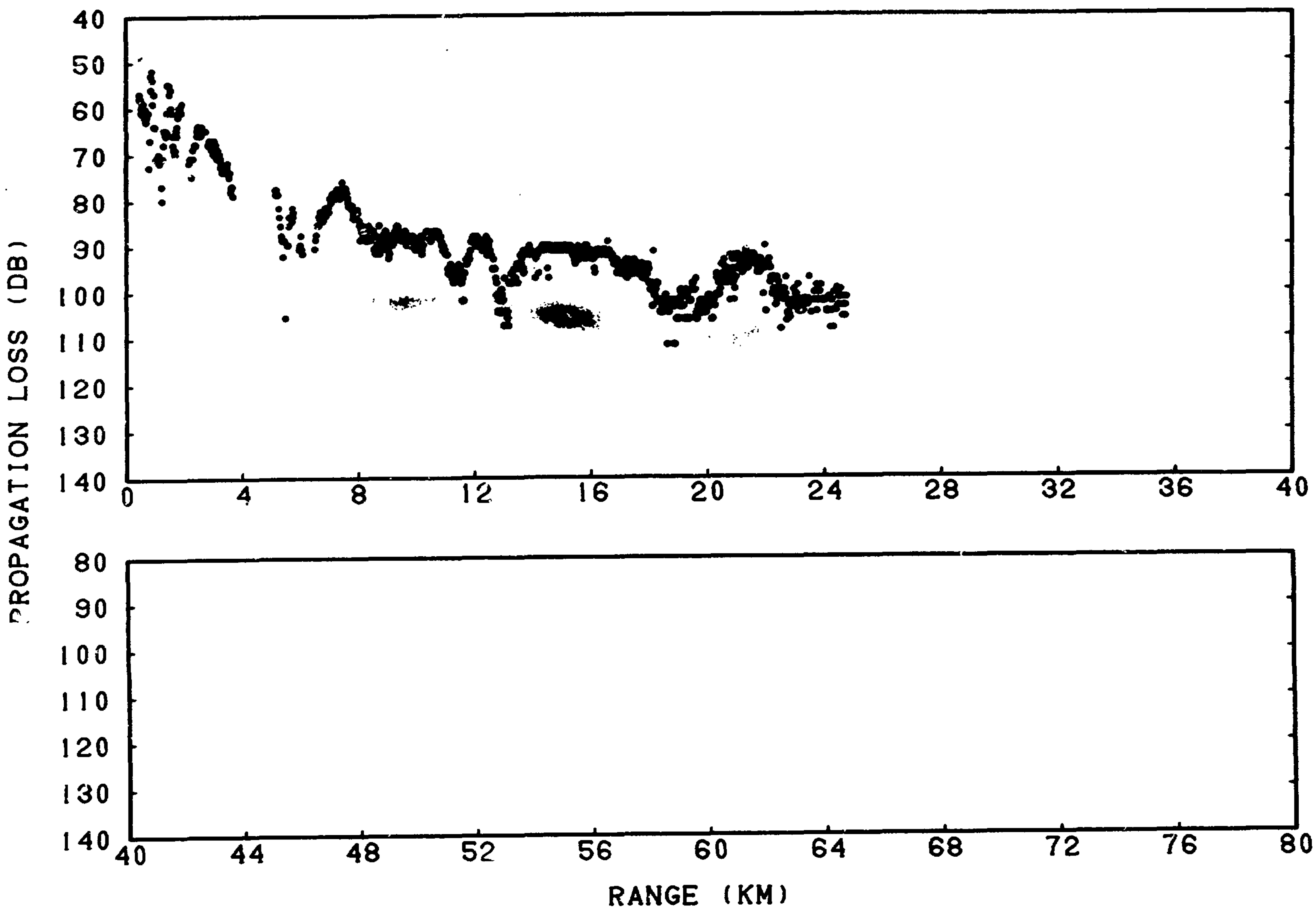
CONFIDENTIAL

(C) Figure IIIA-7. SUDS Data, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters



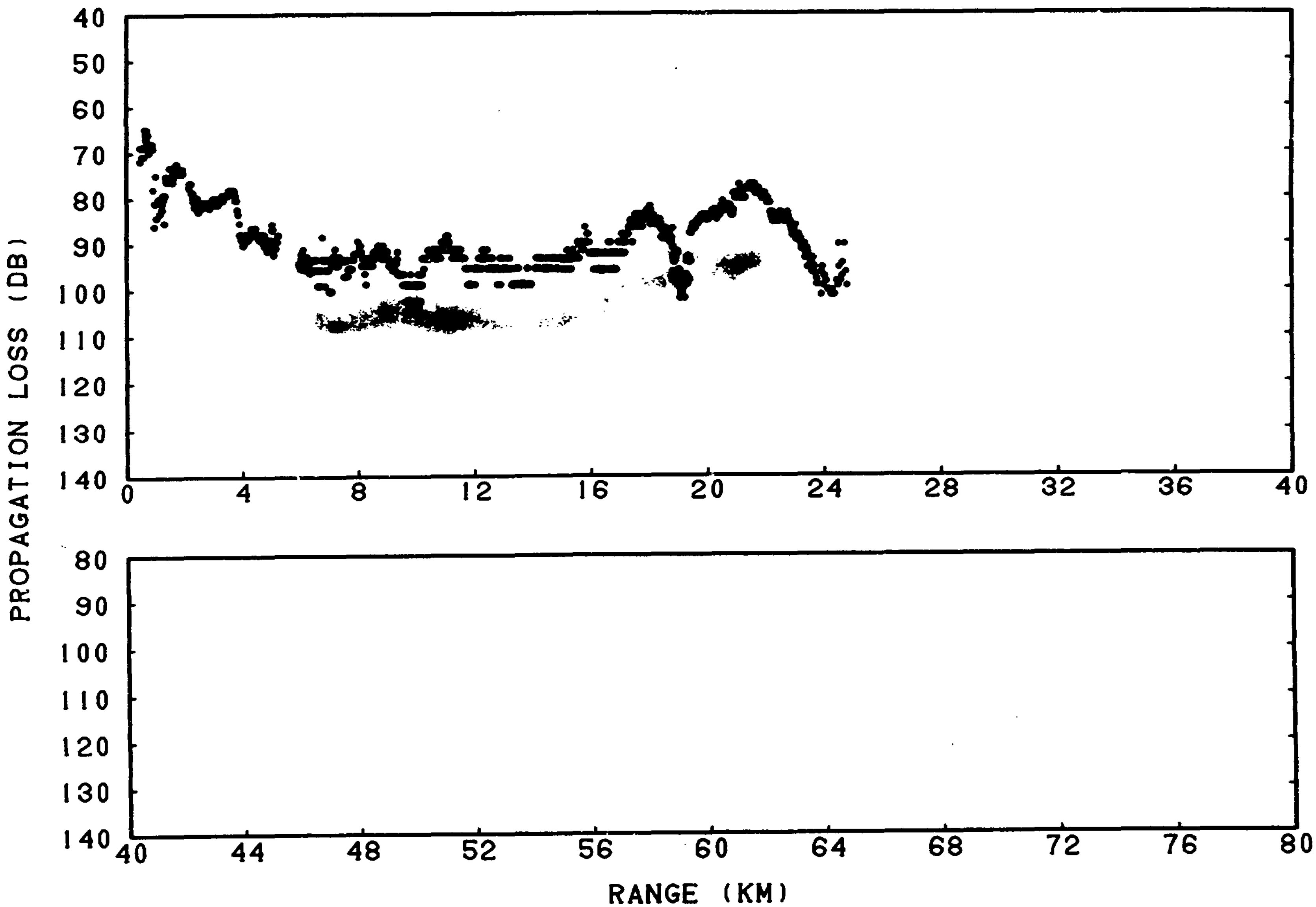
CONFIDENTIAL

(C) Figure IIIA-8. SUDS Data, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters



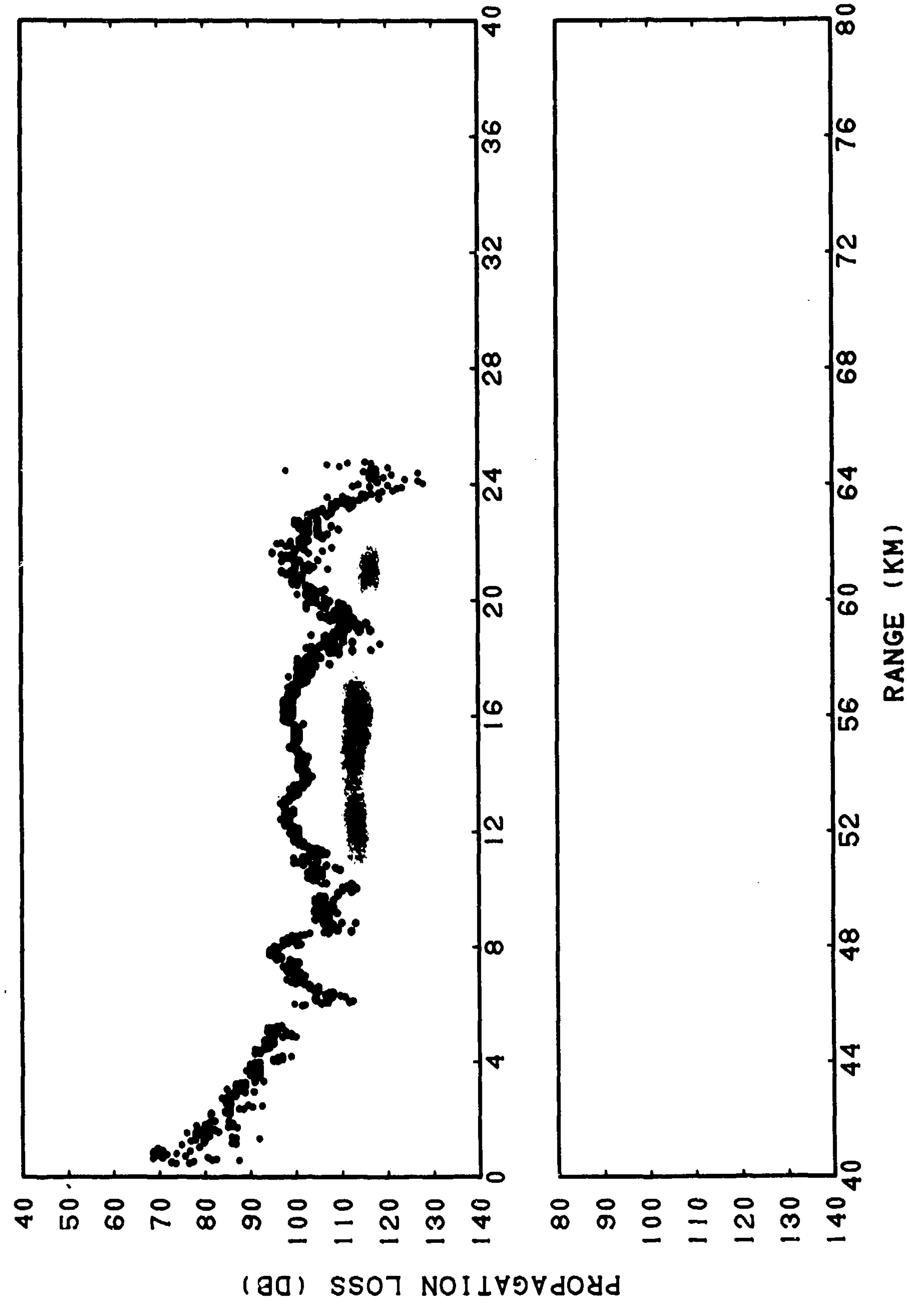
CONFIDENTIAL

(C) Figure IIIA-9. SUDS Data, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters



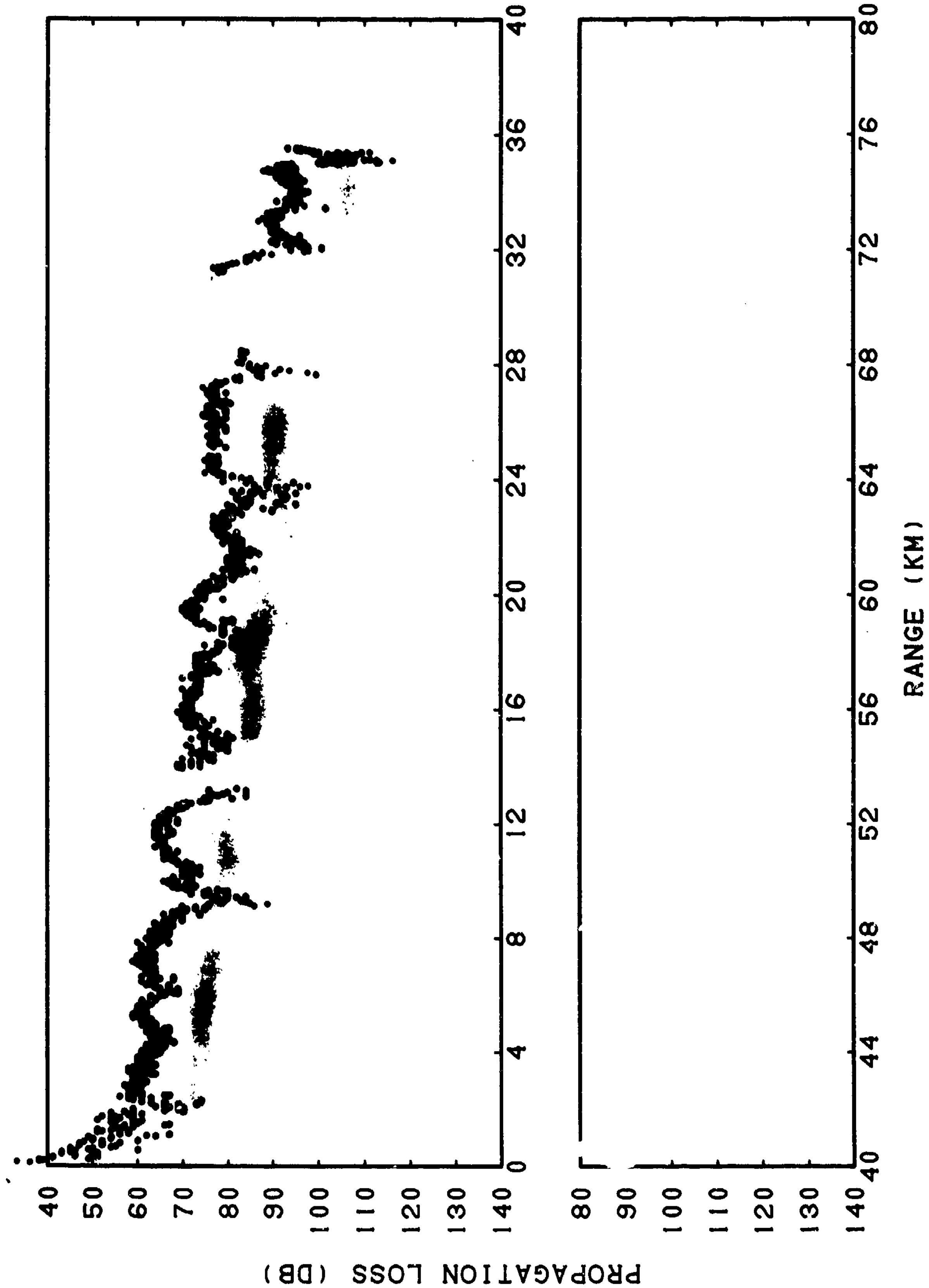
CONFIDENTIAL

(C) Figure IIIA-10. SUDS Data, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters



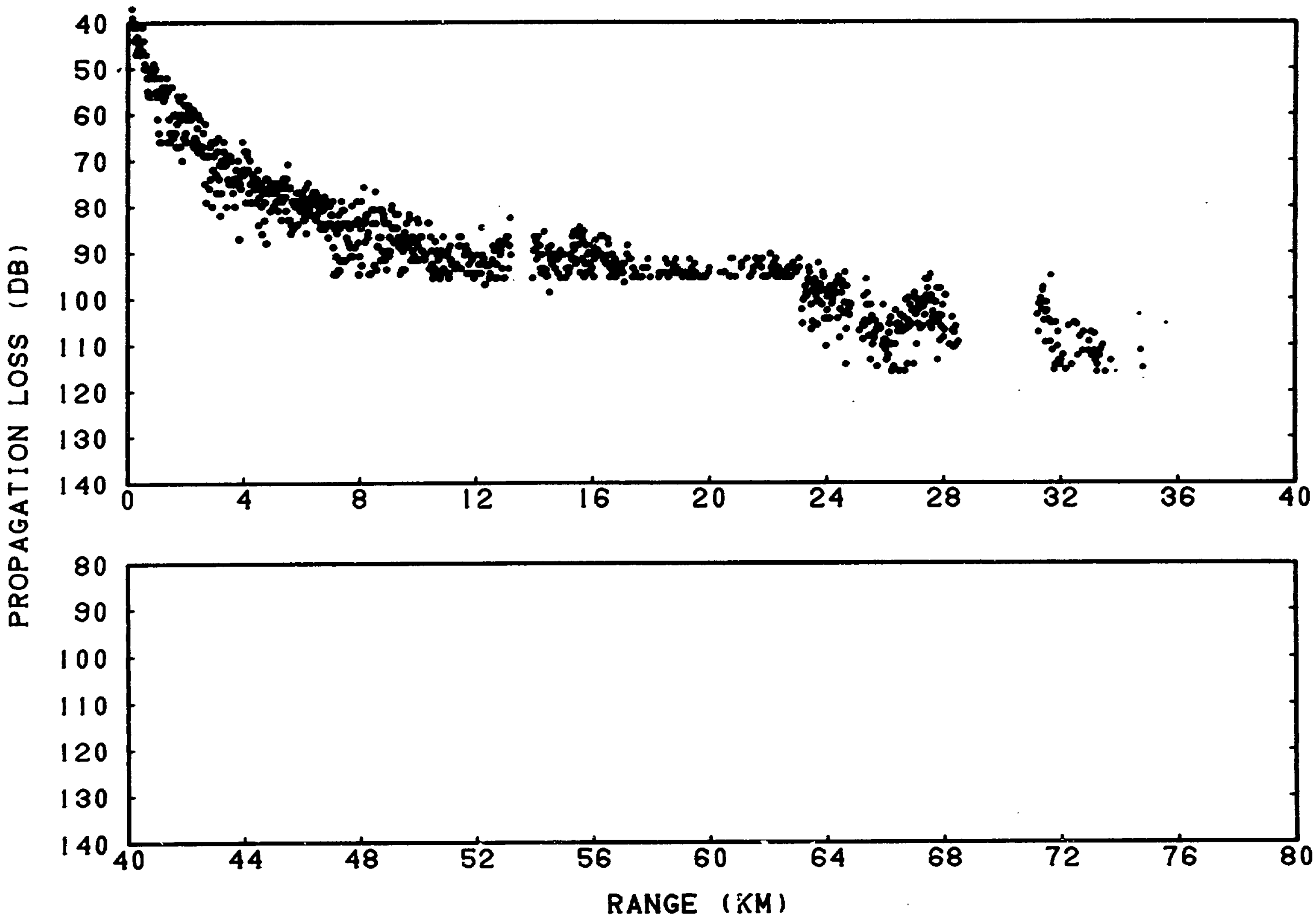
CONFIDENTIAL

(C) Figure IIIA-11. SUDS Data, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters



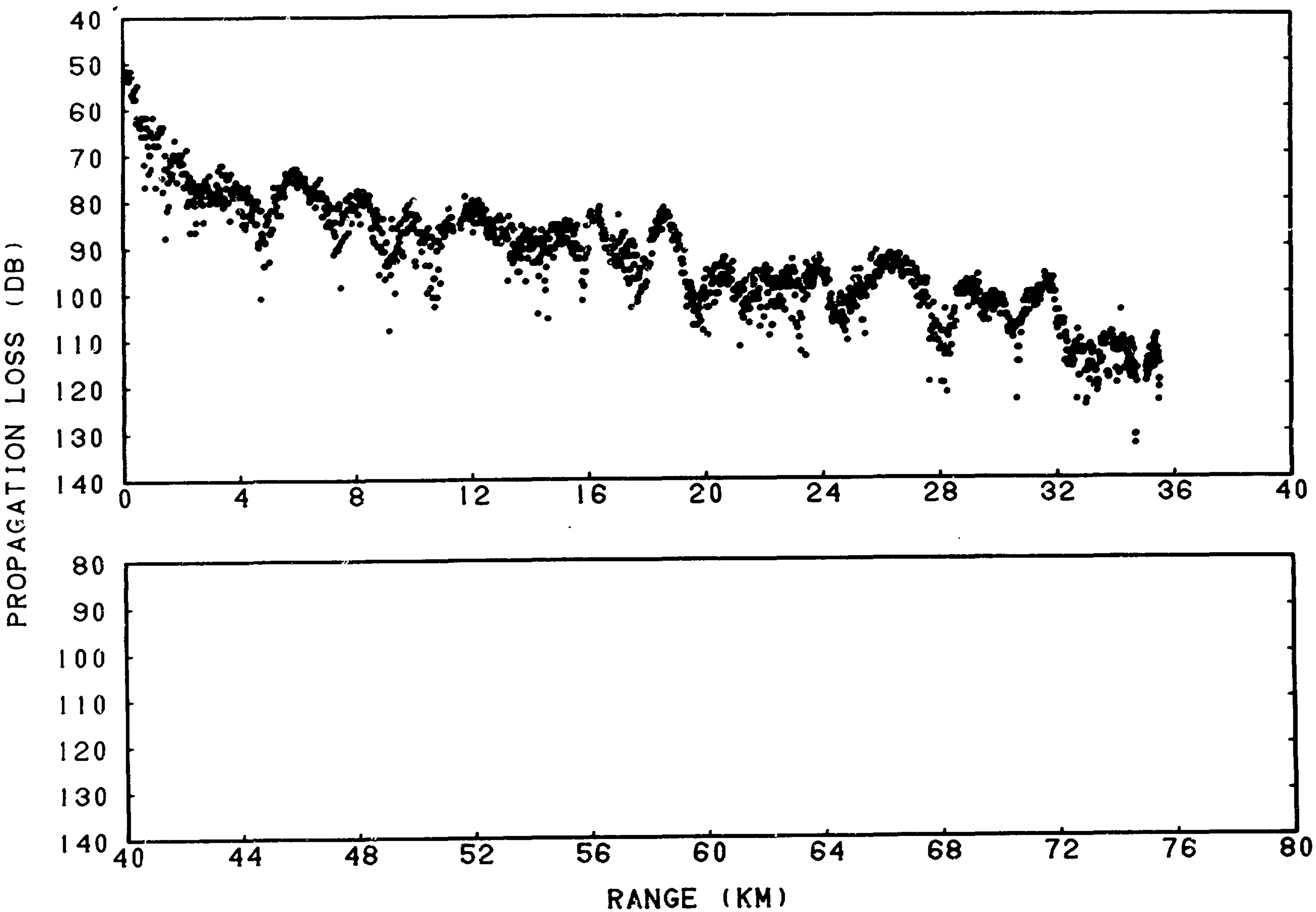
CONFIDENTIAL

(C) Figure IIIA-12. SUDS Data, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters



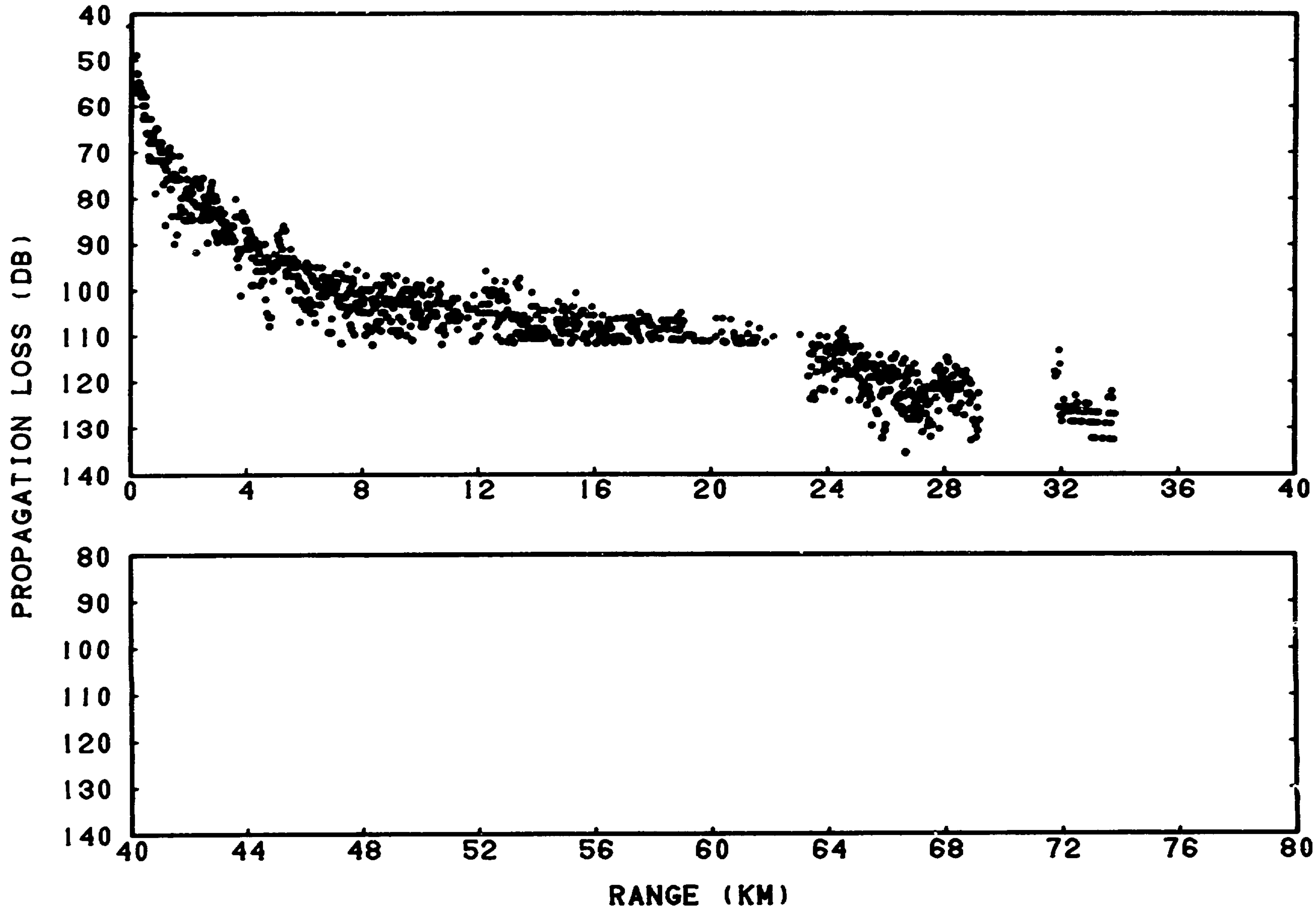
CONFIDENTIAL

(C) Figure IIIA-13. SUDS Data, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters



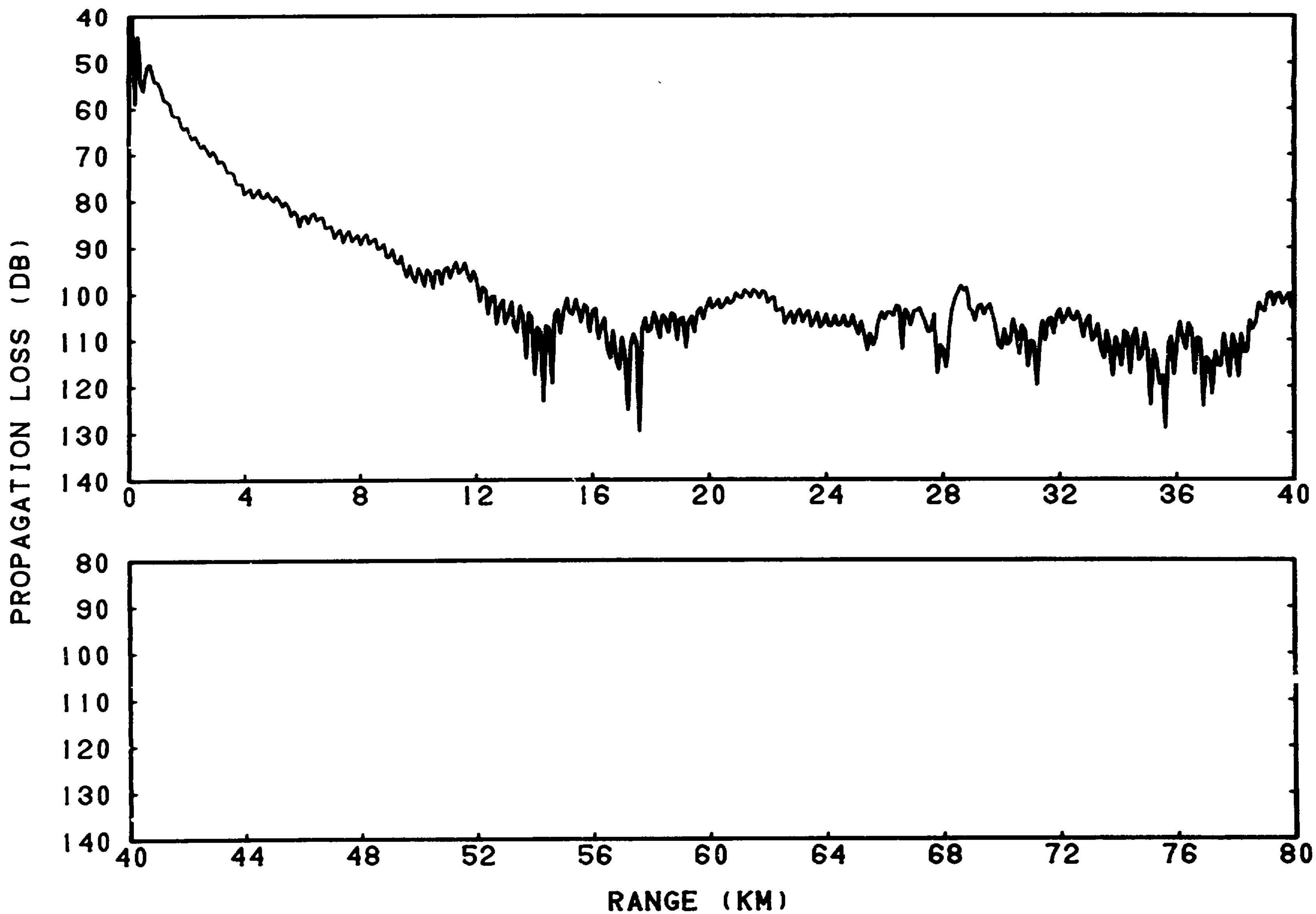
CONFIDENTIAL

(C) Figure IIIA-14. SUDS Data, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 17 Meters



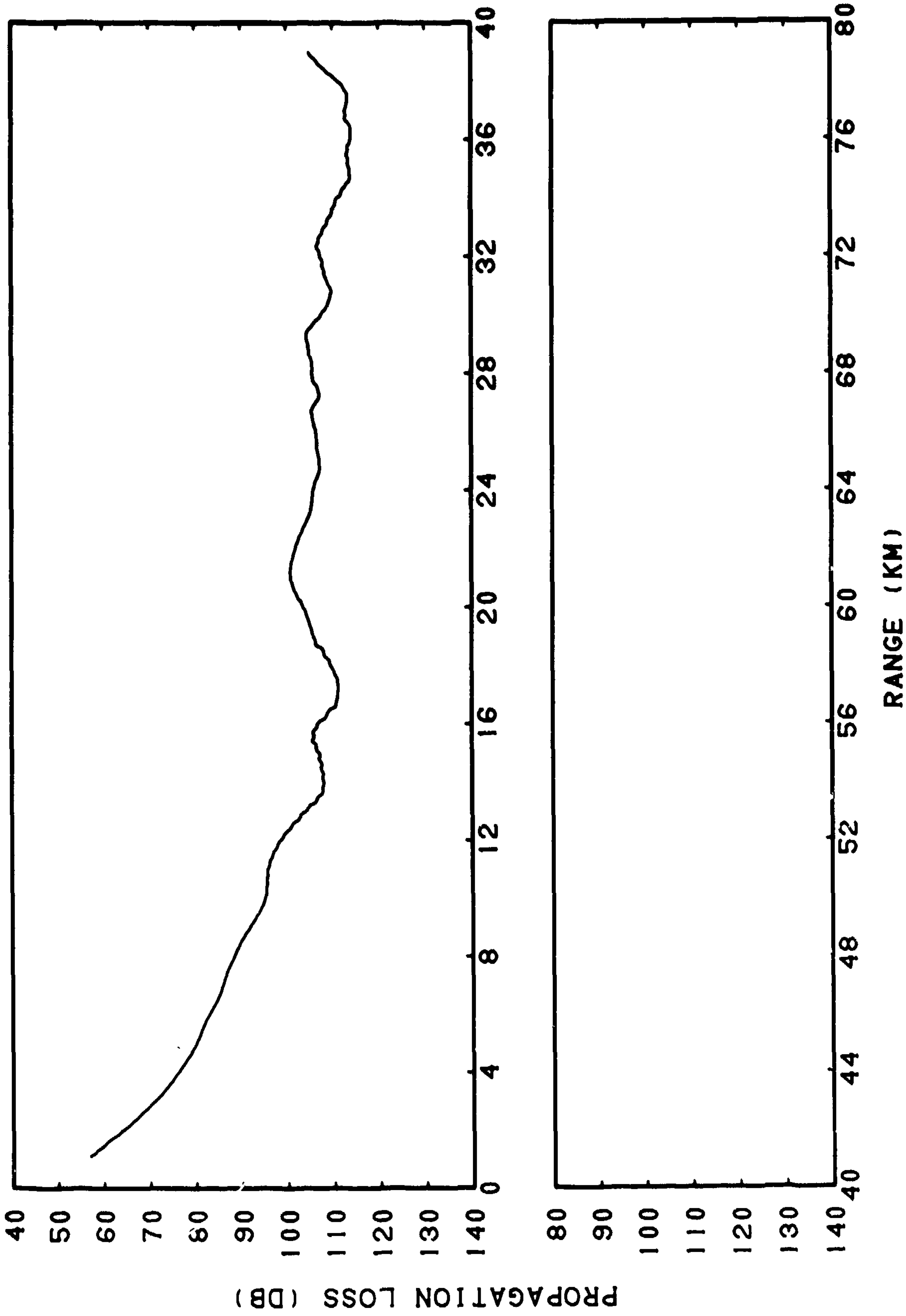
CONFIDENTIAL

(C) Figure IIIA-15. SUDS Data, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 17 Meters



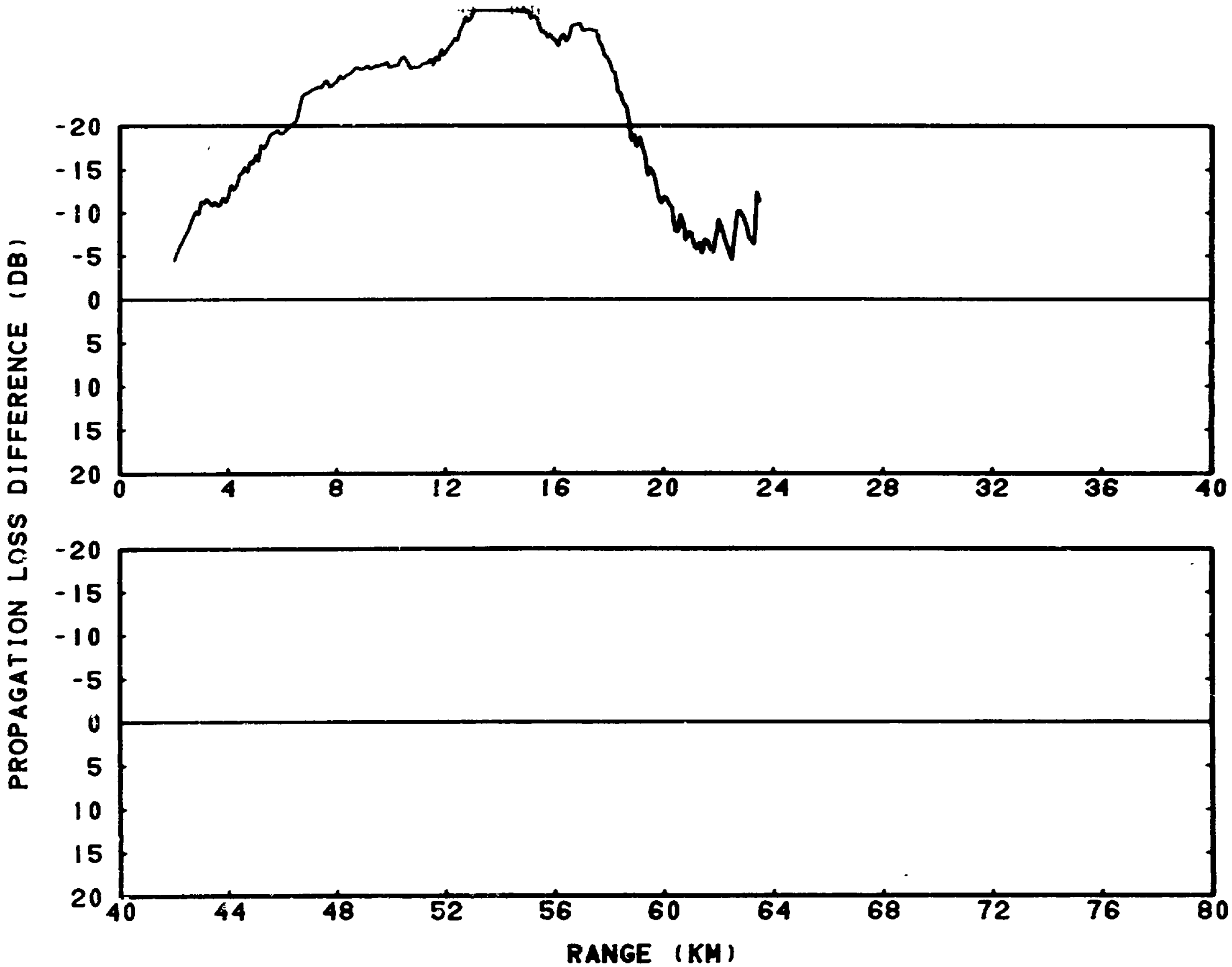
CONFIDENTIAL

(C) Figure IIIA-16. CASE I. RAYMODE Coherent, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters



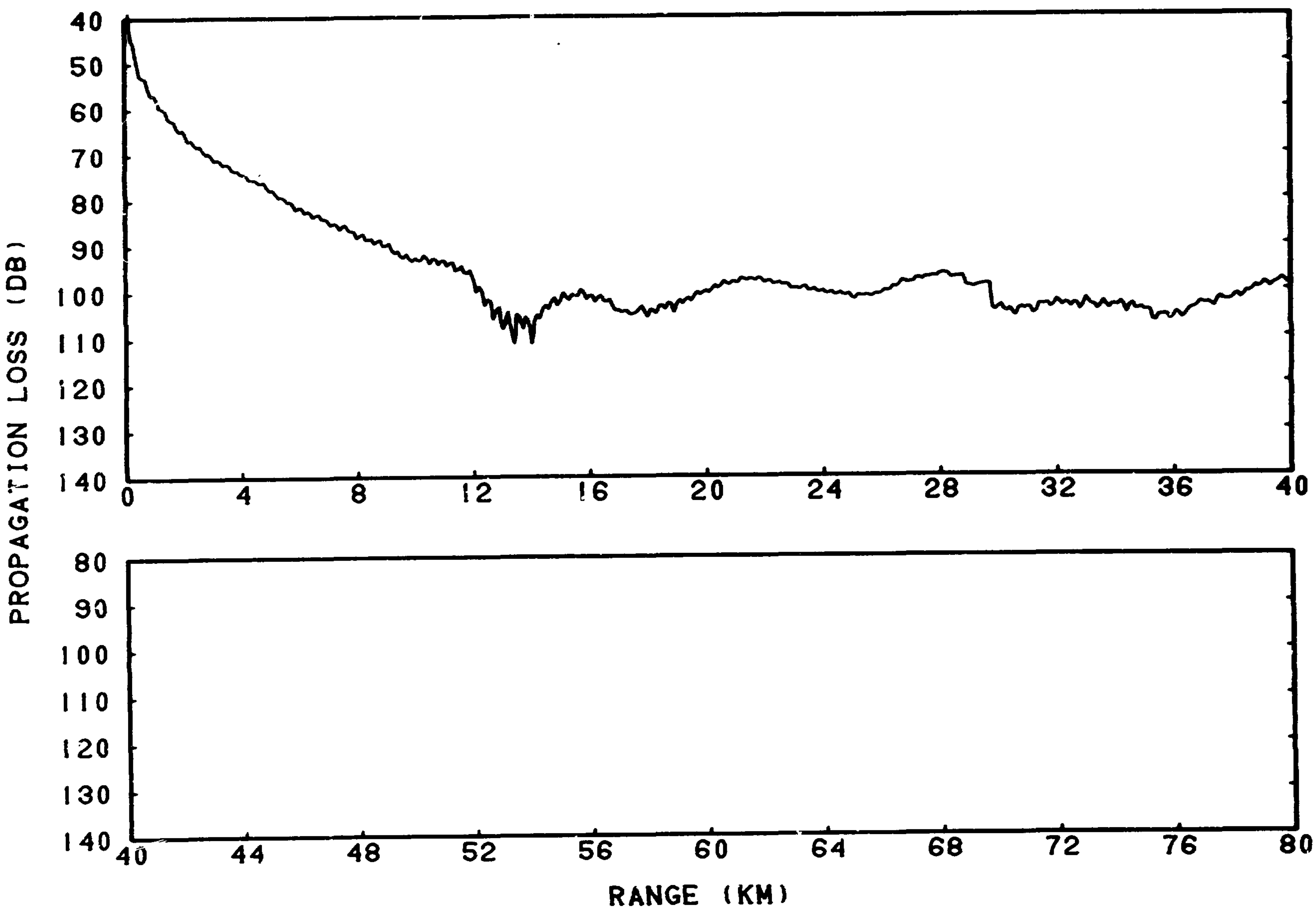
CONFIDENTIAL

(C) Figure IIIA-17. CASE I. RAYMODE Coherent, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters, Sliding Averages of 21 Points (1.99 Kilometer)



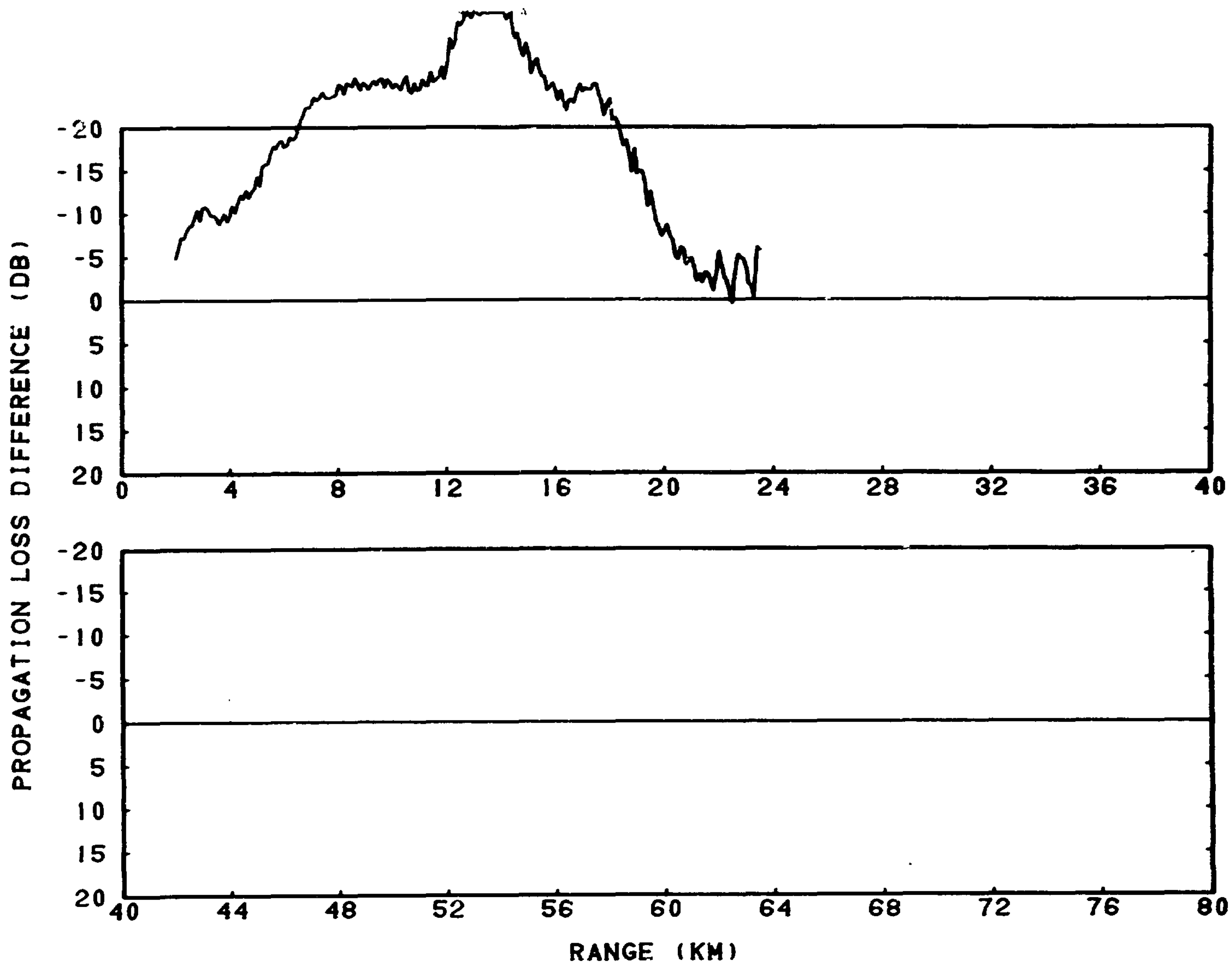
CONFIDENTIAL

(C) Figure IIIA-18. CASE I. Smoothed RAYMODE Coherent, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters, Subtracted from SUDS Data, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters



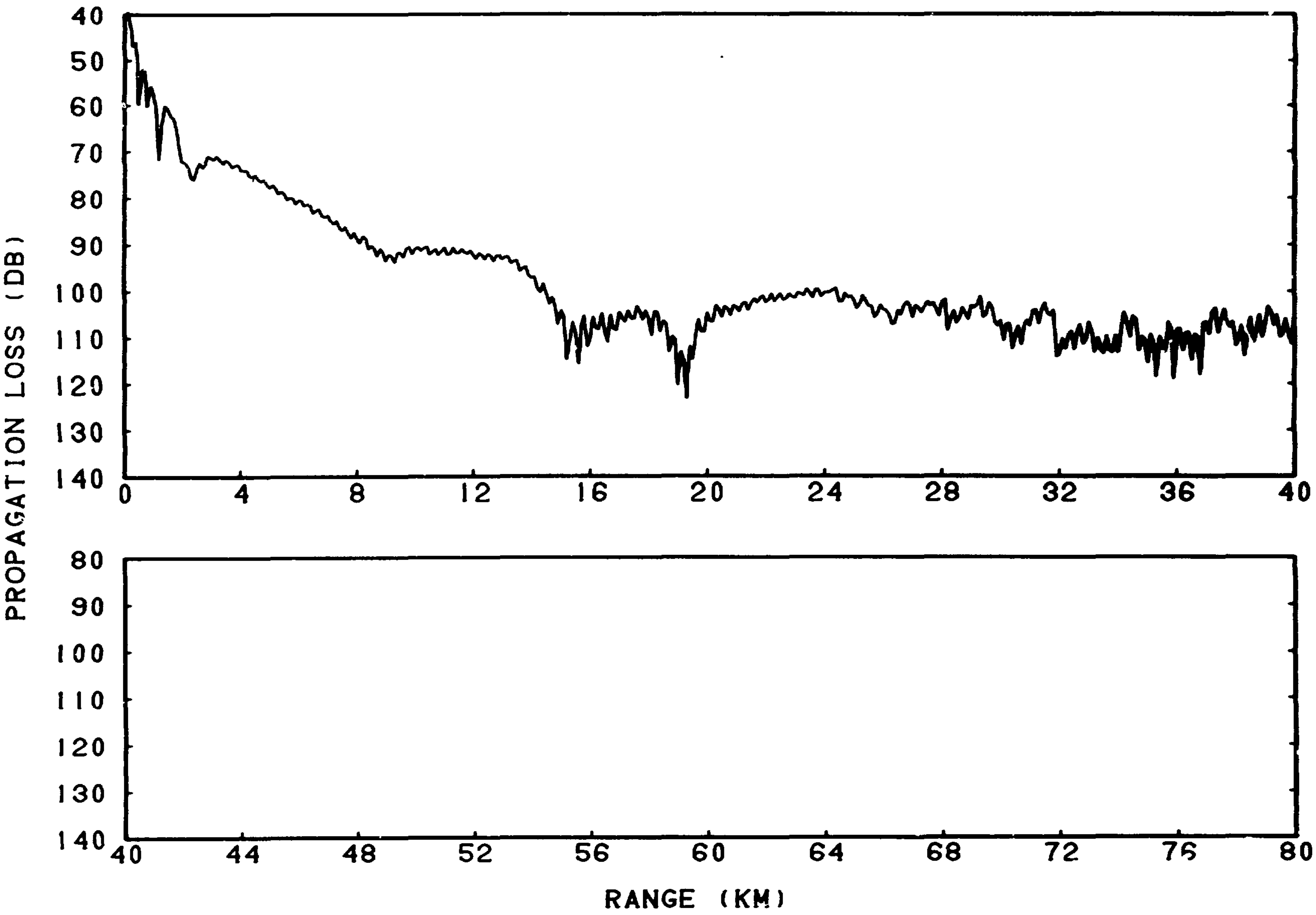
CONFIDENTIAL

(C) Figure IIIA-19. CASE I. RAYMODE Incoherent, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters



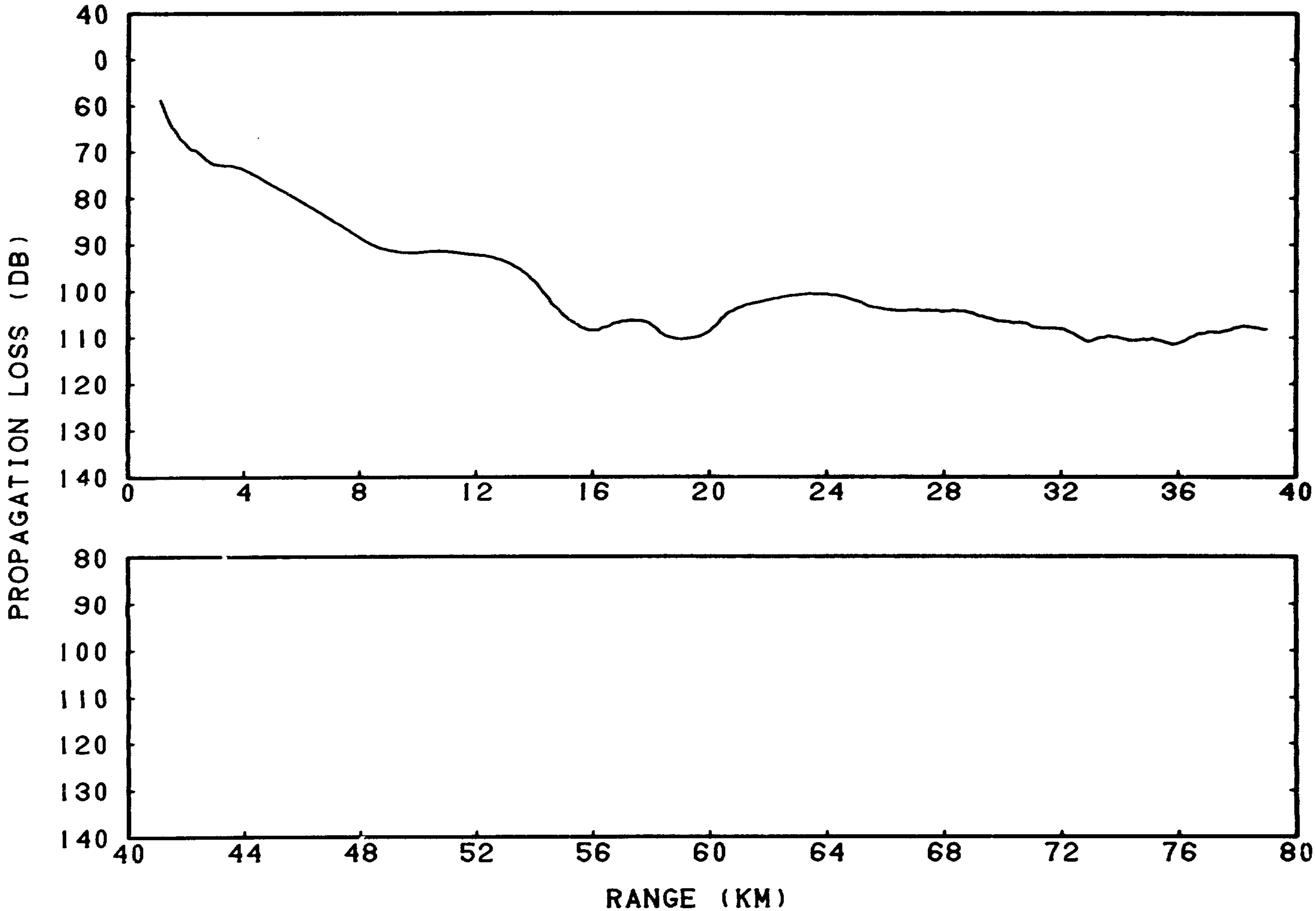
CONFIDENTIAL

(C) Figure IIIA-20. CASE I. RAYMODE Incoherent, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters, Subtracted from SUDS Data, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters



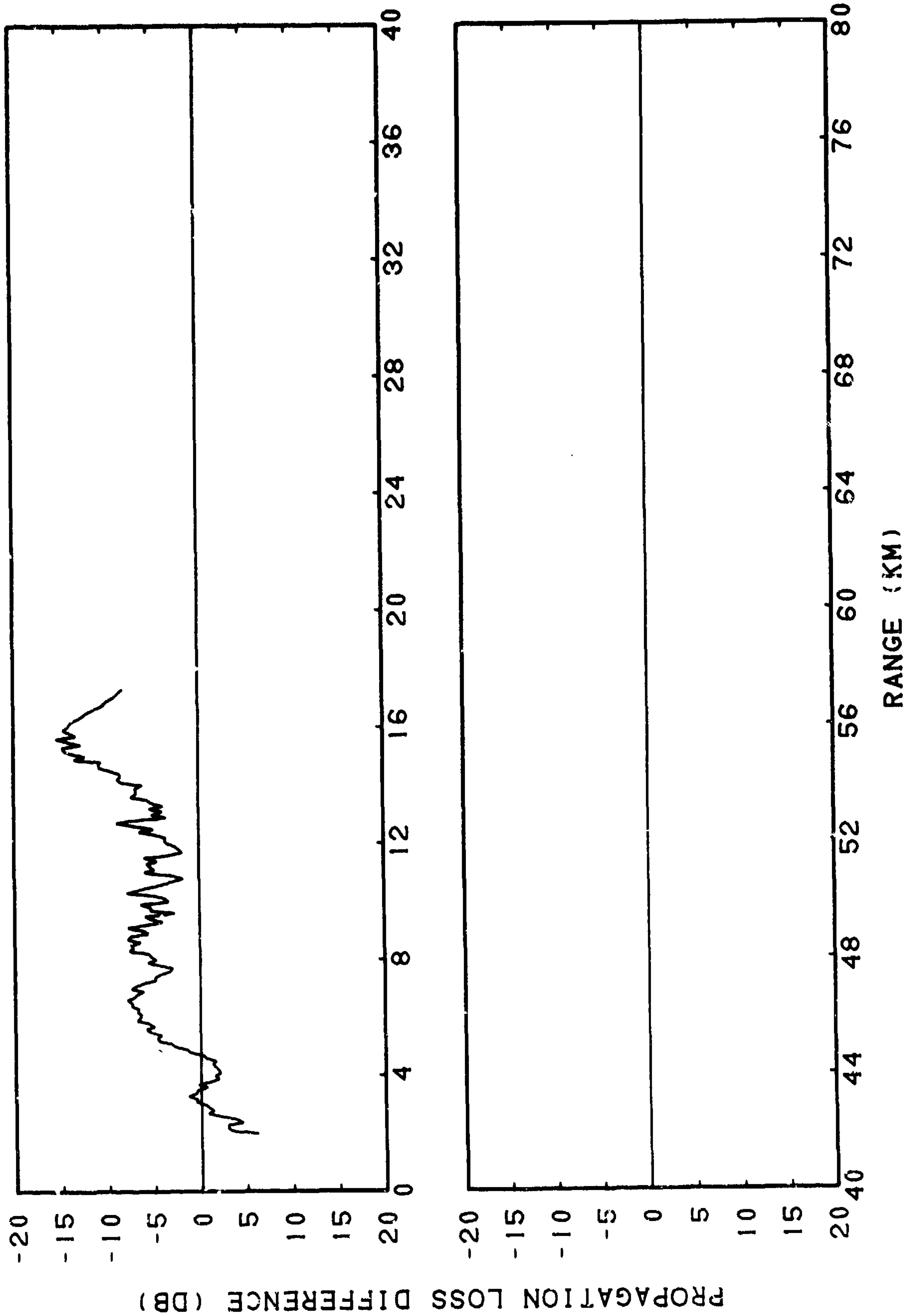
CONFIDENTIAL

(C) Figure IIIA-21. CASE II. RAYMODE Coherent, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters



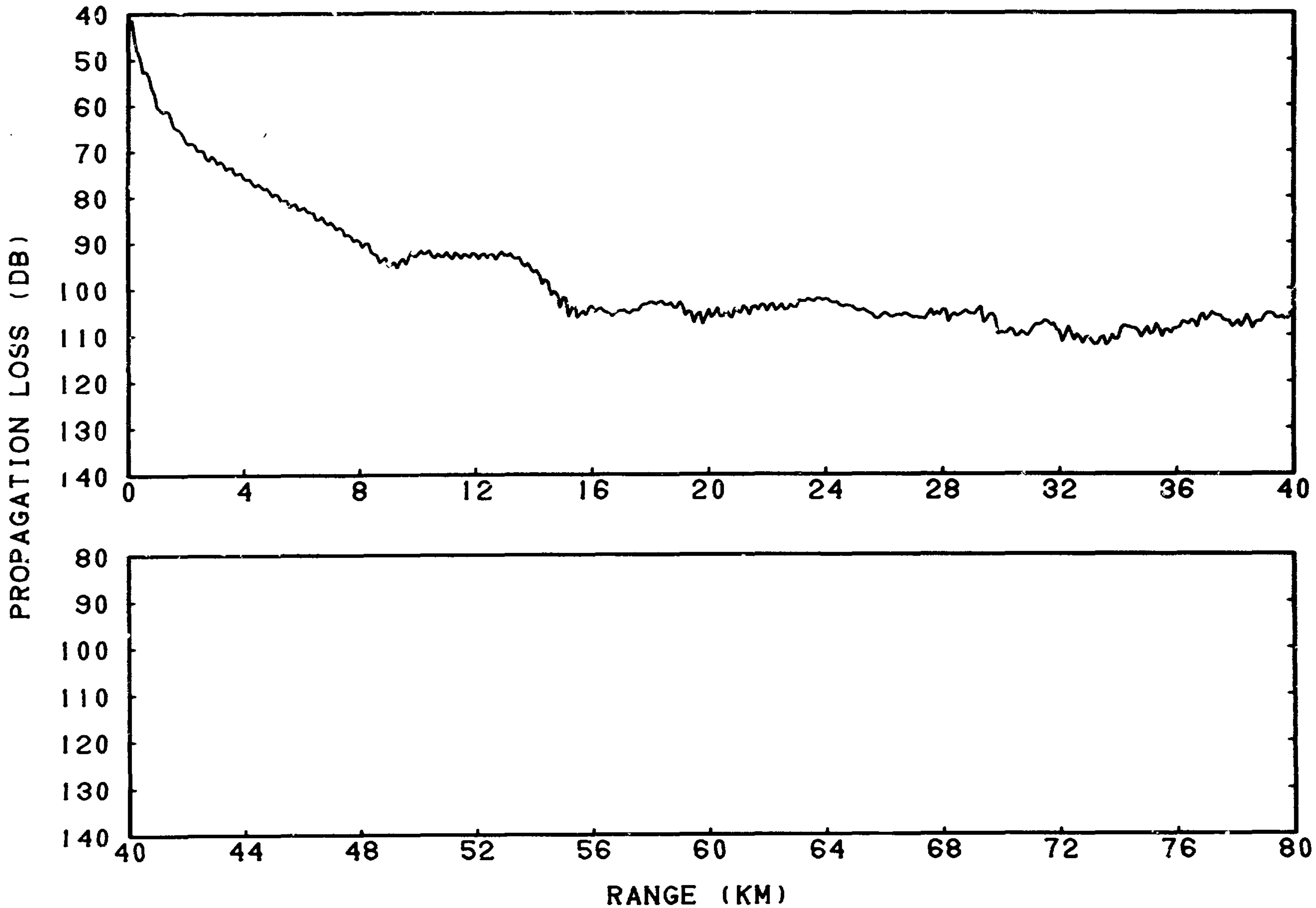
CONFIDENTIAL

(C) Figure IIIA-22. CASE II. RAYMODE Coherent, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters, Sliding Averages of 21 Points (1.99 Kilometer)



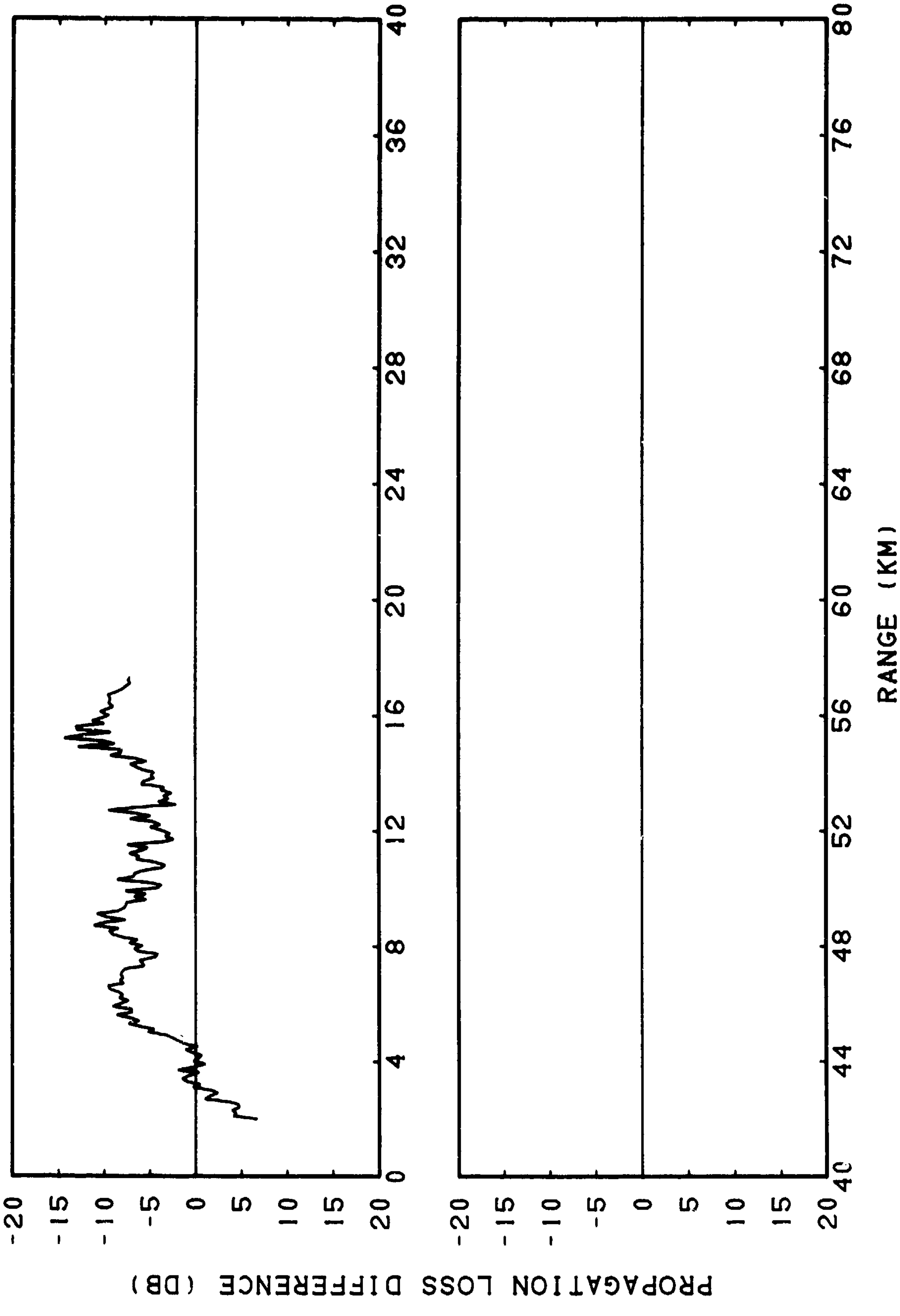
CONFIDENTIAL

(C) Figure IIIA-23. CASE II. Smoothed RAYMODE Coherent, Frequency = 0.4 Kilohertz Source Depth = 45 Meters, Receiver Depth = 112 Meters, Subtracted from SUDS Data, Frequency = 0.4 Kilohertz Source Depth = 45 Meters, Receiver Depth = 112 Meters



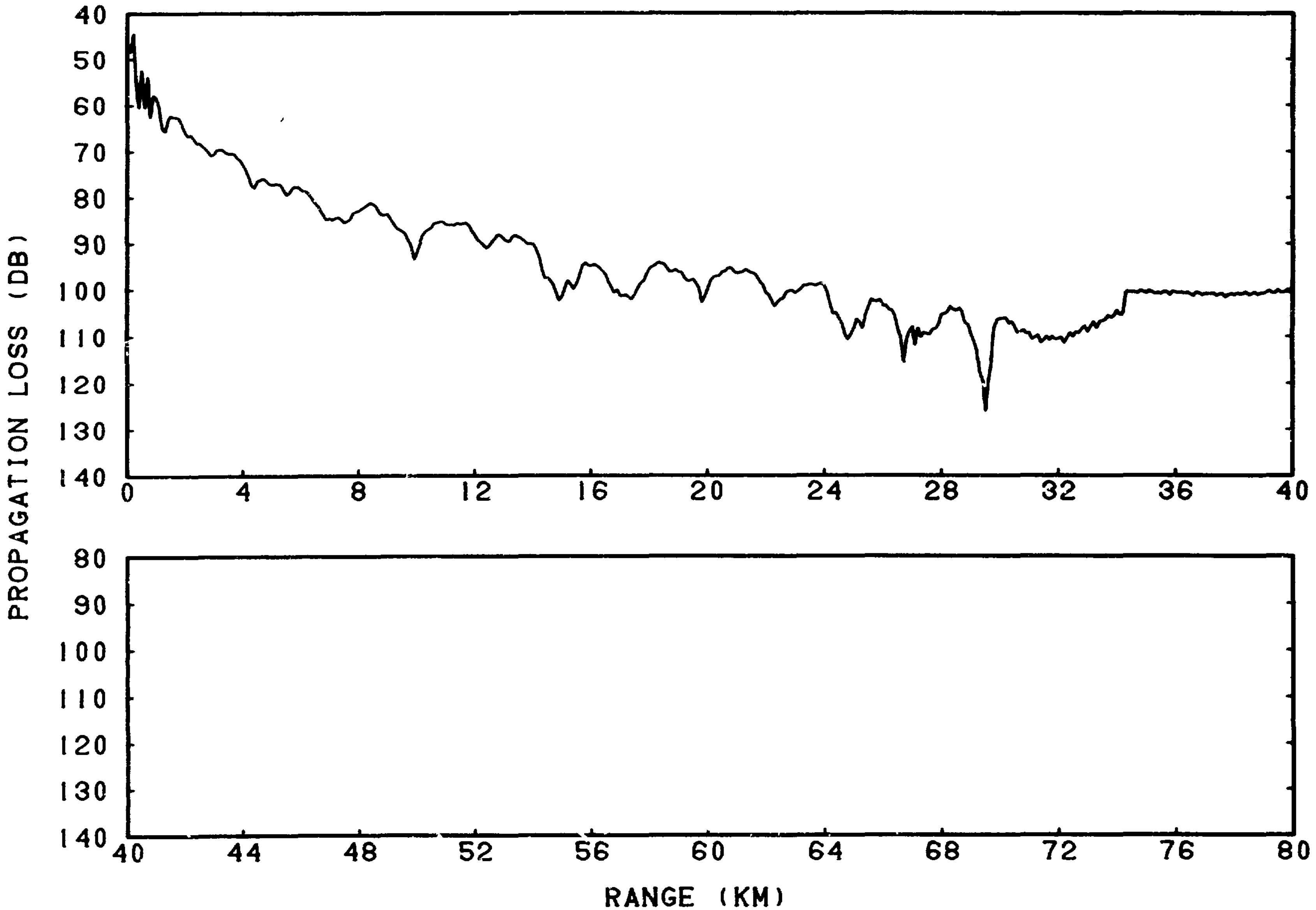
CONFIDENTIAL

(C) Figure IIIA-24. CASE II. RAYMODE Incoherent, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters



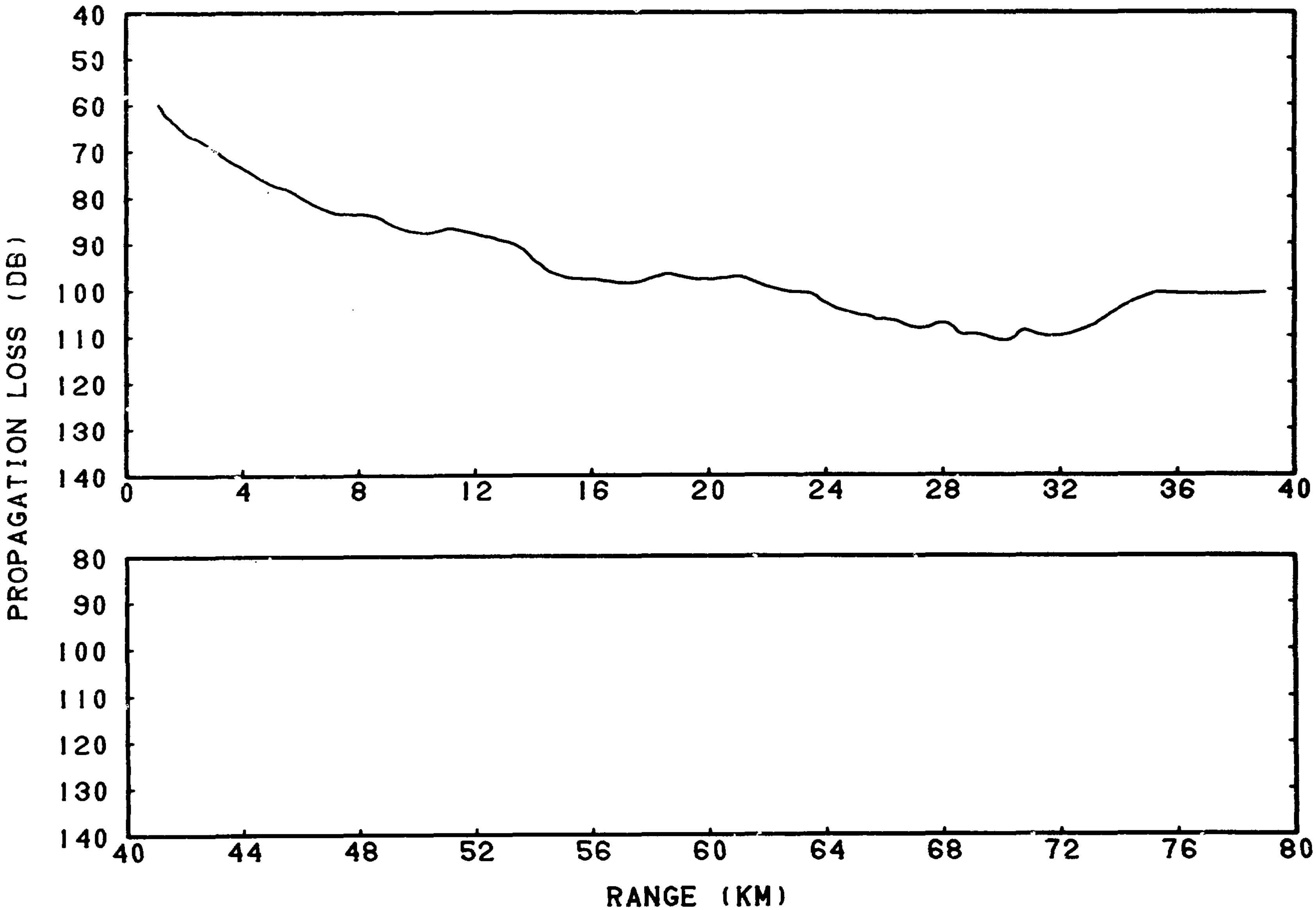
CONFIDENTIAL

(C) Figure IIIA-25. CASE II. RAYMODE Incoherent, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters, Subtracted from SUDS Data, Frequency = 0.4 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters



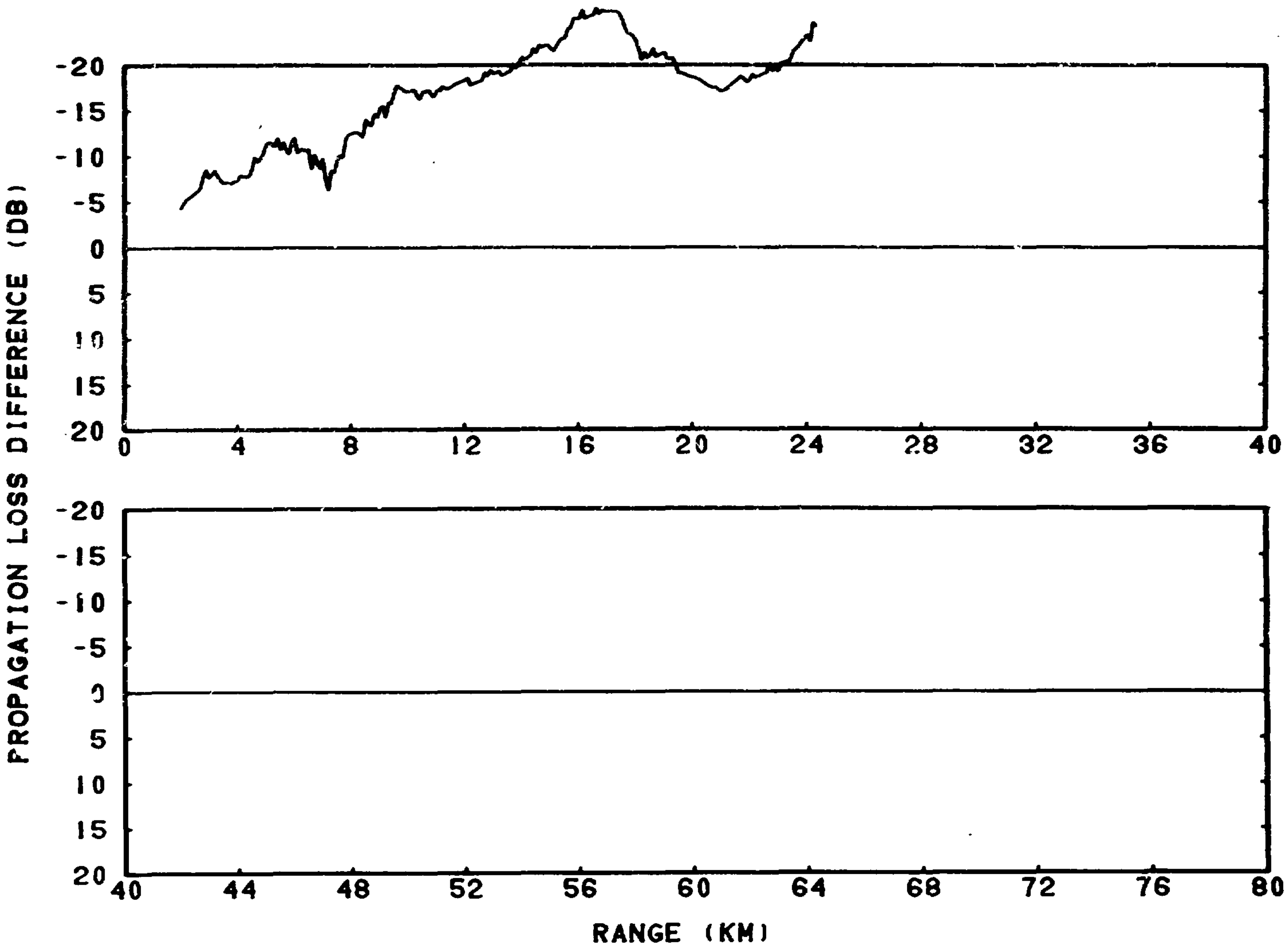
CONFIDENTIAL

(C) Figure IIIA-26. CASE III. RAYMODE Coherent, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 43 Meters



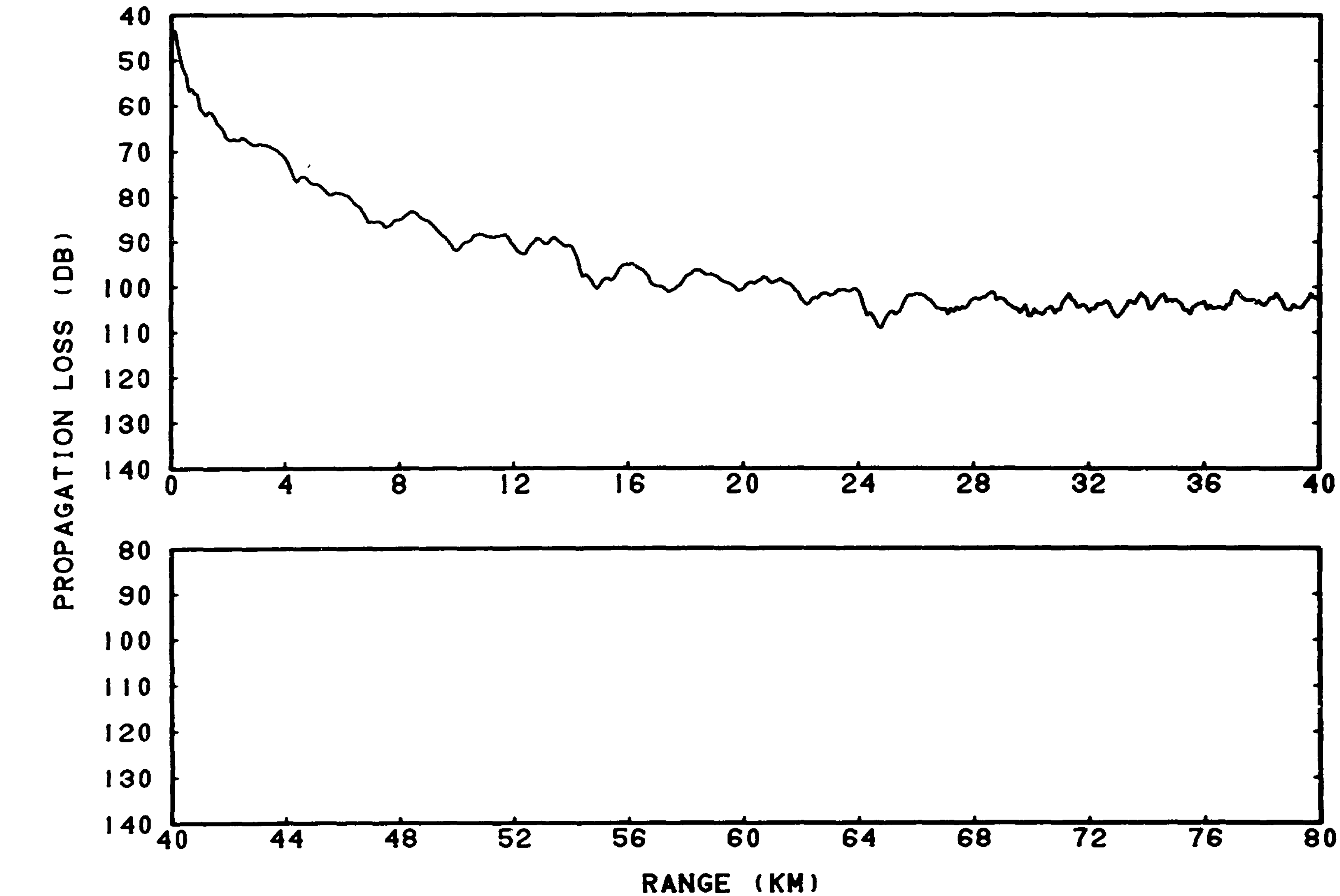
CONFIDENTIAL

(C) Figure IIIA-27. CASE III. RAYMODE Coherent, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 43 Meters, Sliding Averages of 21 Points (1.99 Kilometer)



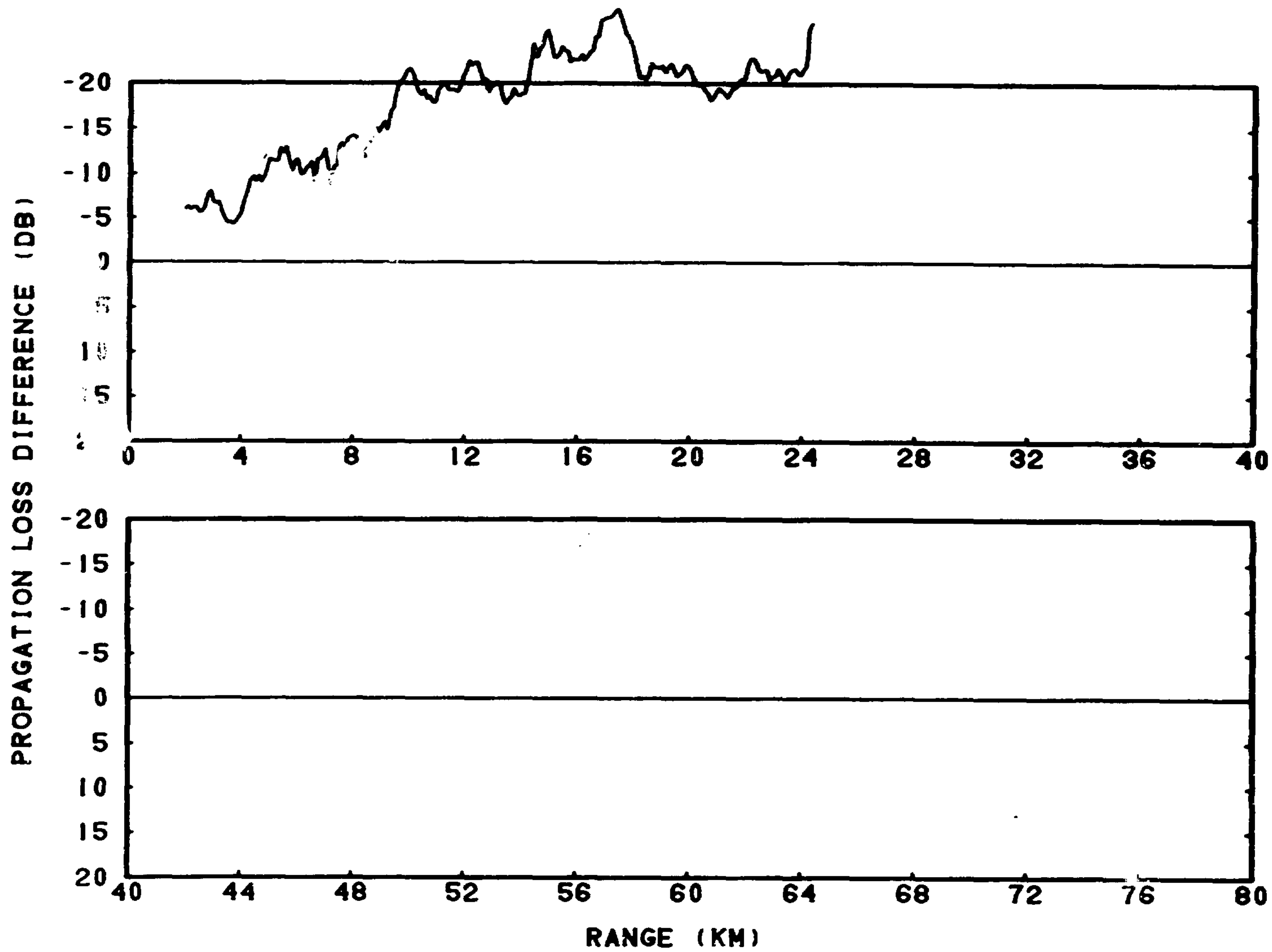
CONFIDENTIAL

(C) Figure IIIA-28. CASE III. Smoothed RAYMODE Coherent, Frequency = 1.0 Kilohertz, Scurce Depth = 42 Meters, Receiver Depth = 43 Meters, Subtracted from SUDS Data, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 43 Meters



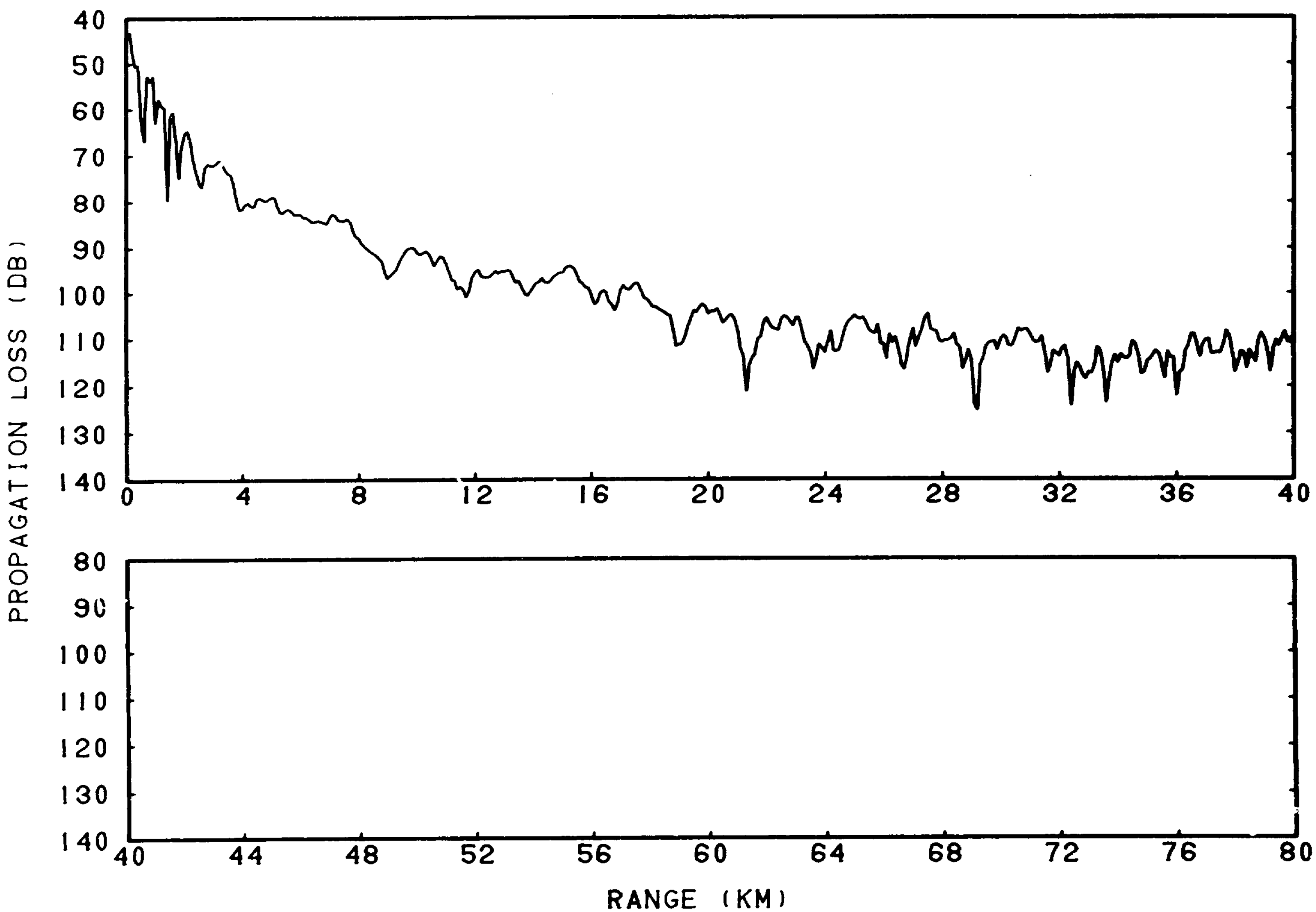
CONFIDENTIAL

(C) Figure IIIA-29. CASE III. RAYMODE Incoherent, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 43 Meters



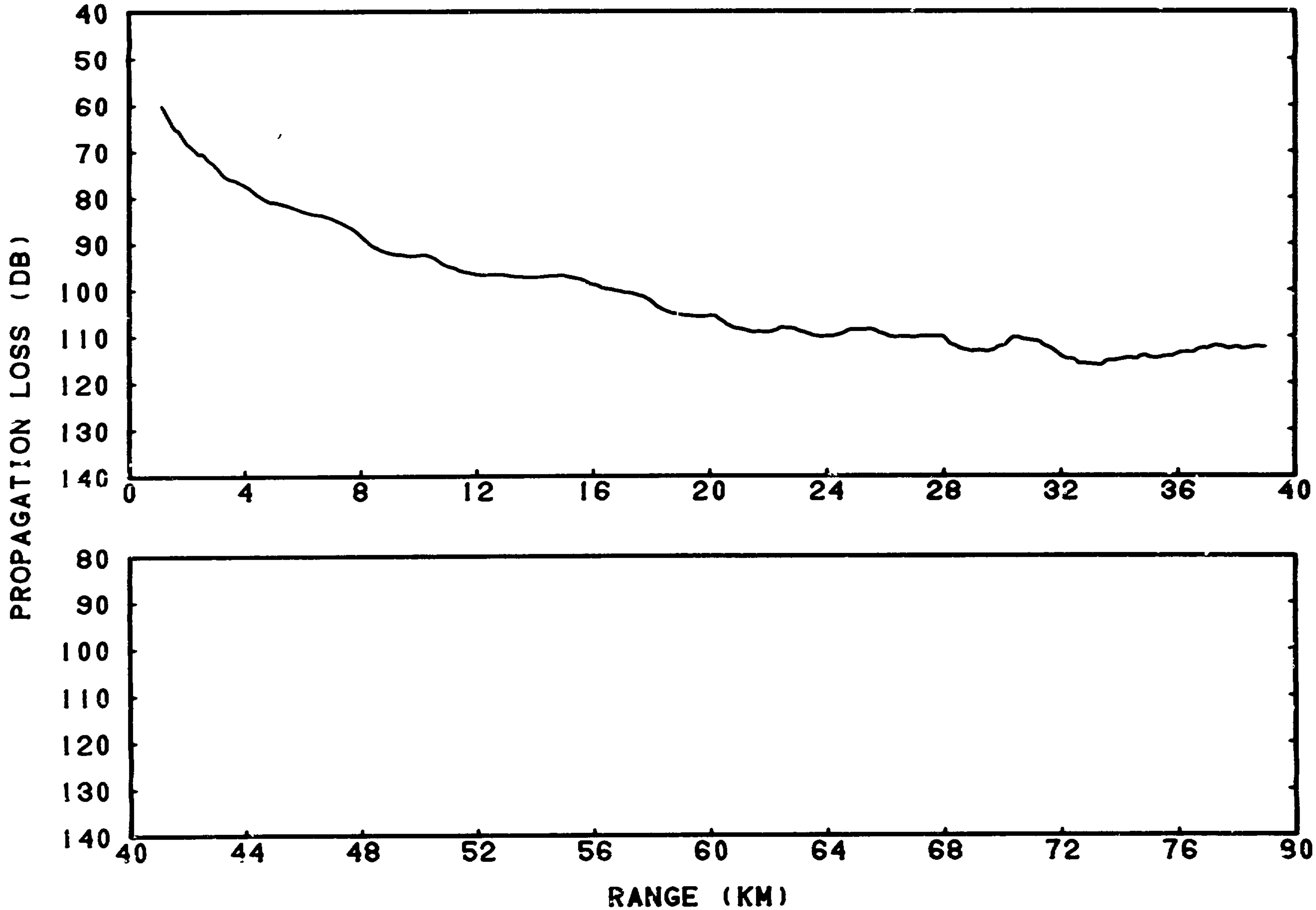
CONFIDENTIAL

(C) Figure IIIA-30. CASE III. RAYMODE Incoherent, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 43 Meters, Subtracted from SUDS Data, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 43 Meters



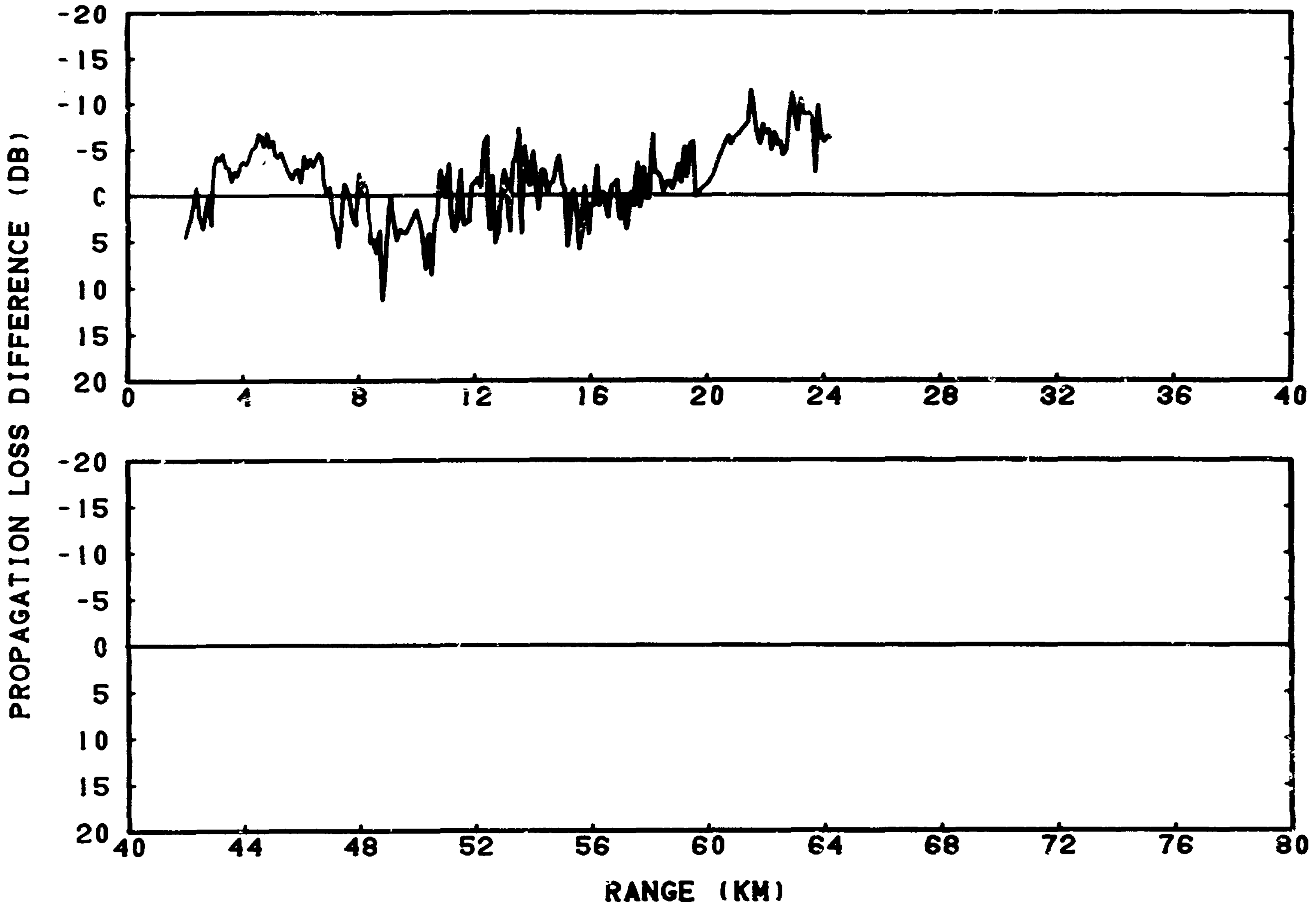
CONFIDENTIAL

(C) Figure IIIA-31. CASE IV. RAYMODE Coherent, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters



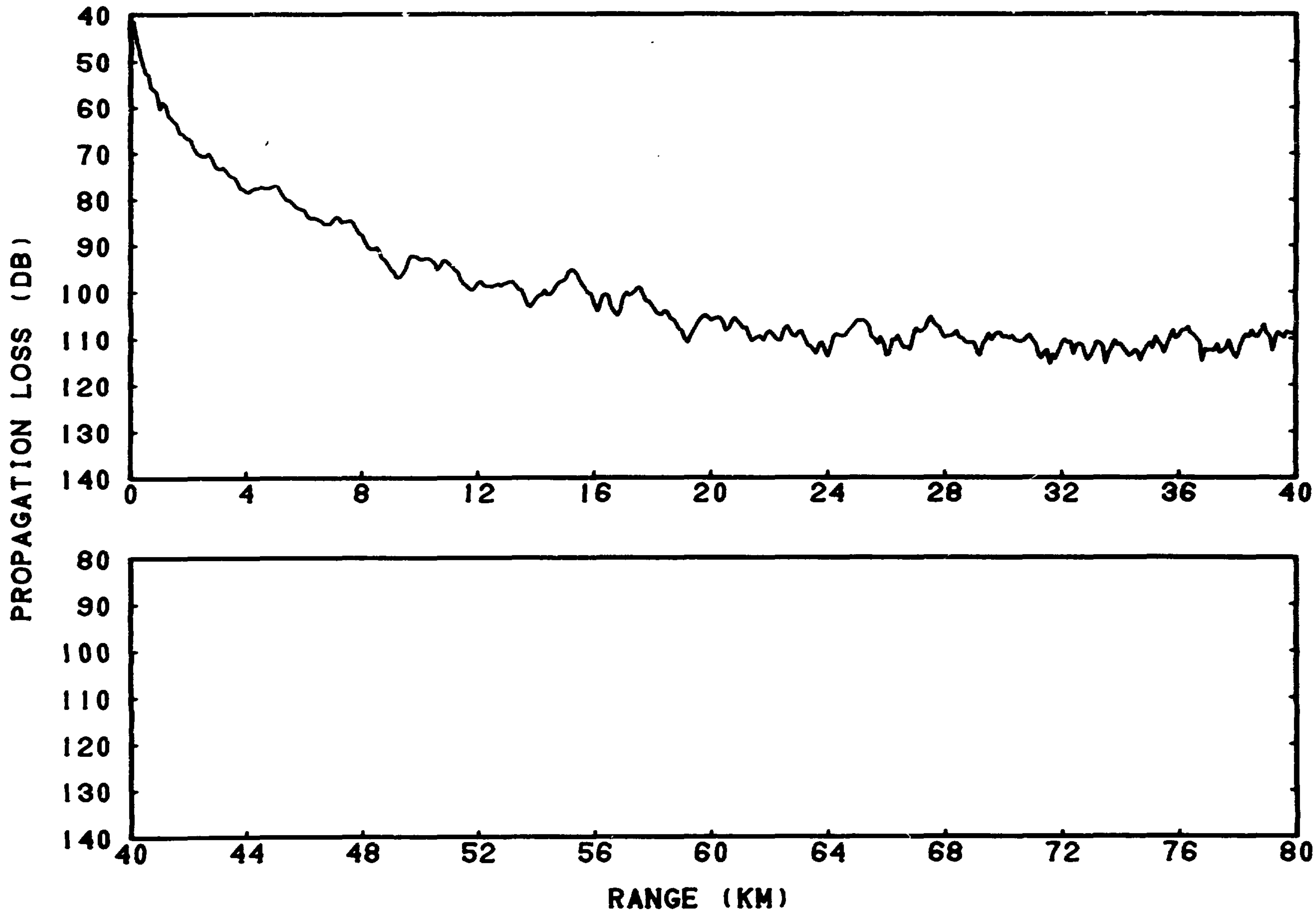
CONFIDENTIAL

(C) Figure IIIA-32. CASE IV. RAYMODE Coherent, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters, Sliding Averages of 21 Points (1.99 Kilometer)



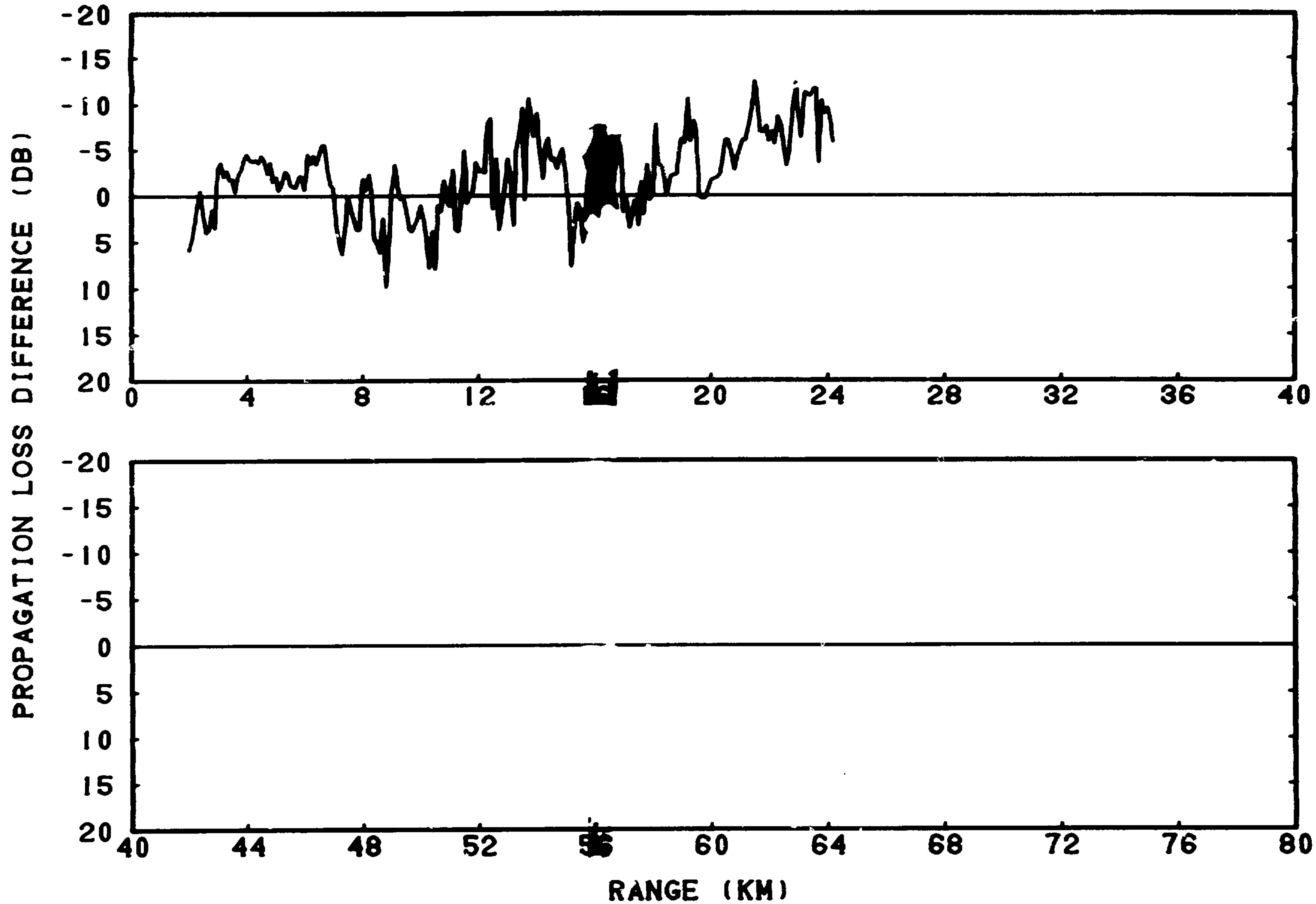
CONFIDENTIAL

(C) Figure IIIA-33. CASE IV. Smoothed RAYMODE Coherent, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters, Subtracted from SUDS Data, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters



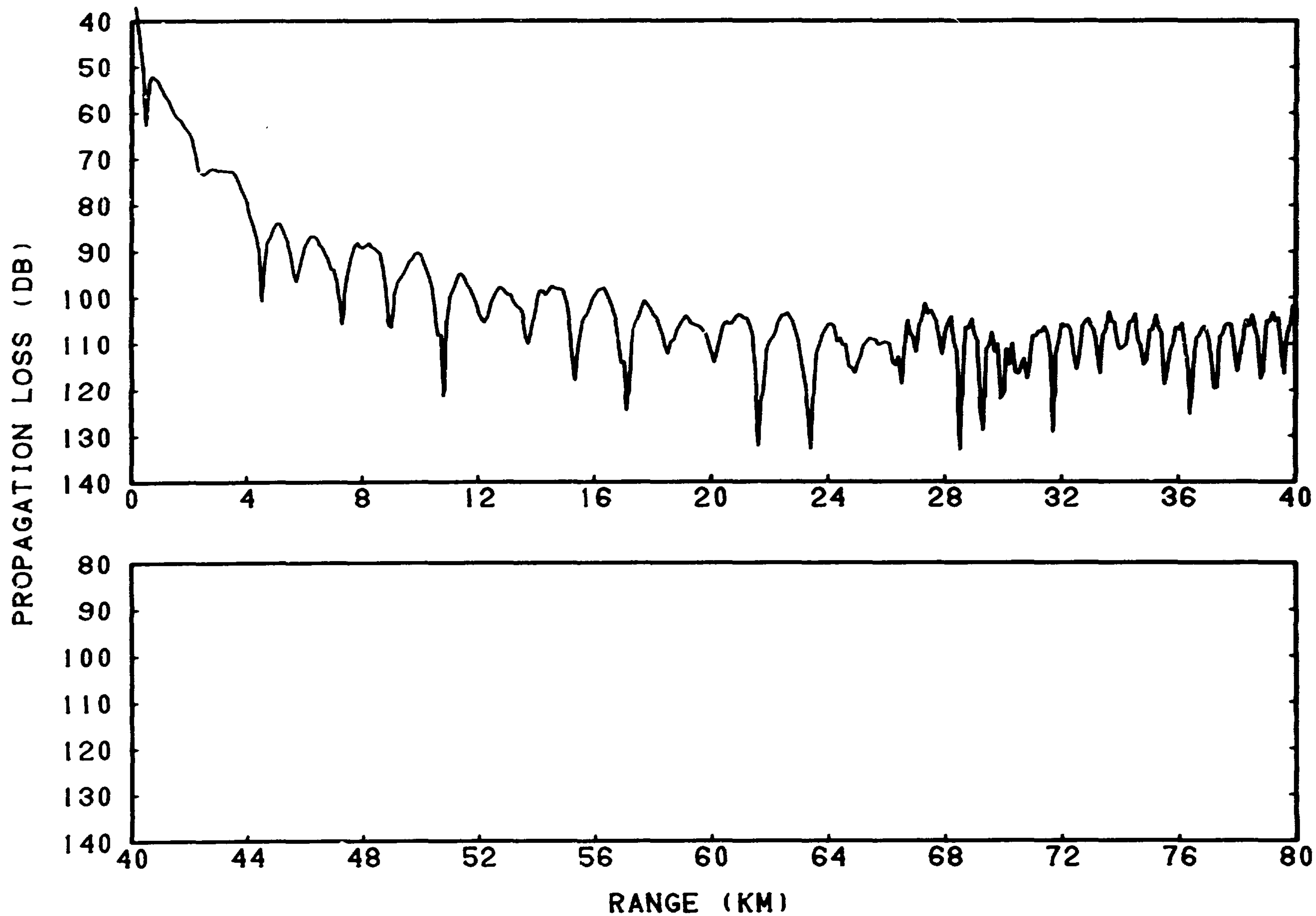
CONFIDENTIAL

(C) Figure IIIA-34. CASE IV. RAYMODE Incoherent, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters



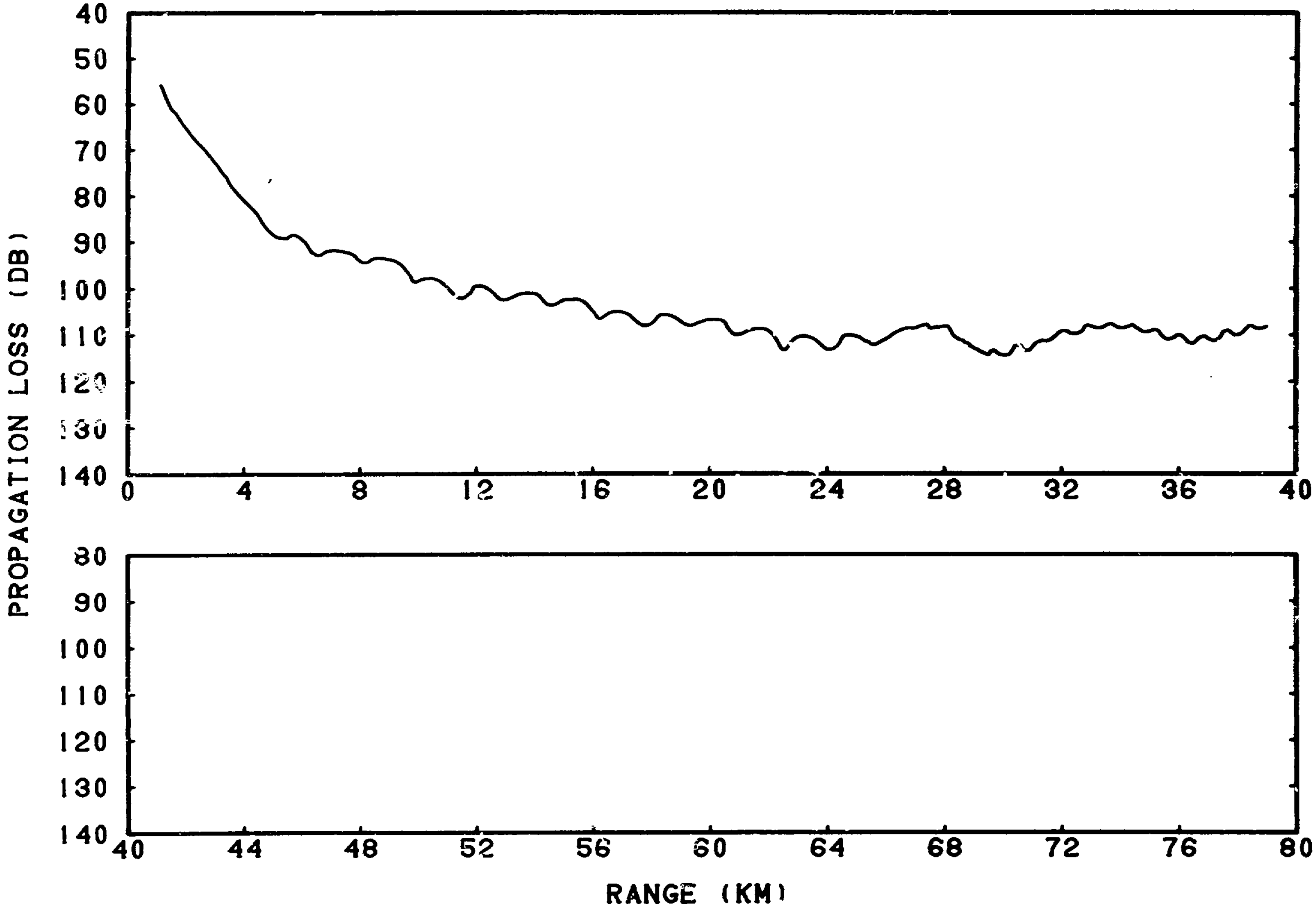
CONFIDENTIAL

(C) Figure IIIA-35. CASE IV. RAYMODE Incoherent, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters, Subtracted from SUDS Data, Frequency = 1.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters



CONFIDENTIAL

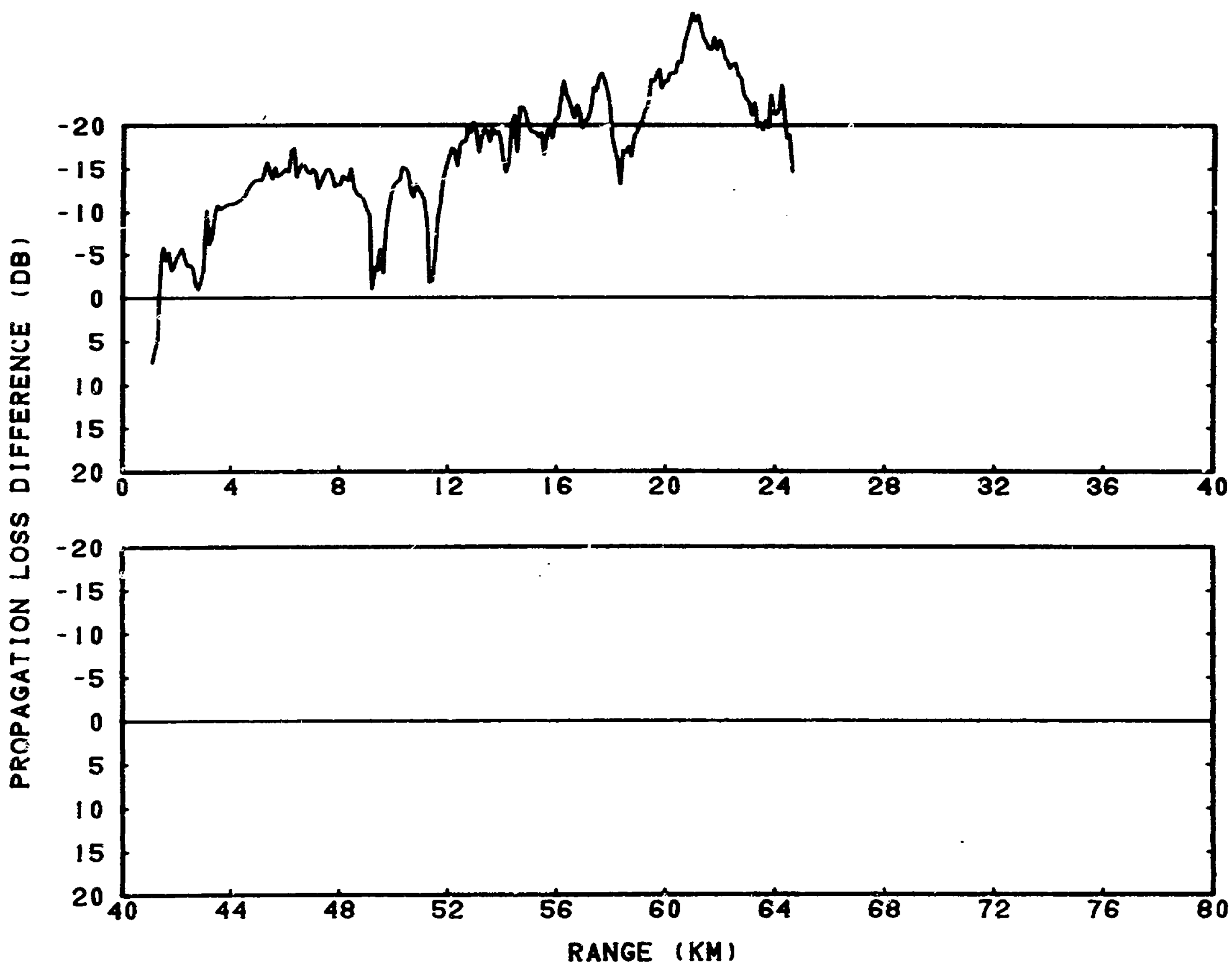
(C) Figure IIIA-36. CASE V. RAYMODE Conerent, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters



CONFIDENTIAL

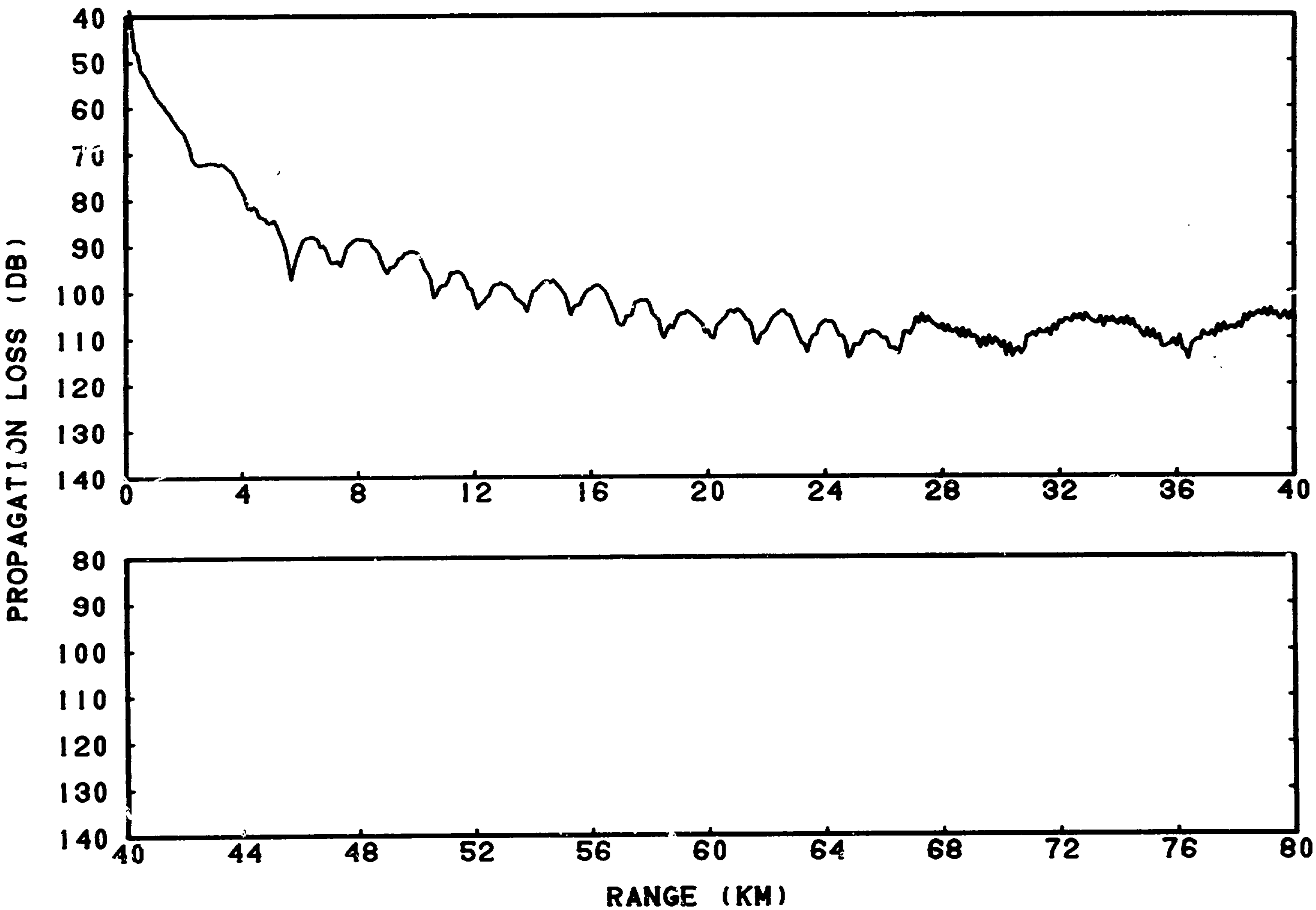
(C) Figure IIIA-37. CASE V. RAYMODE Coherent, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters, Sliding Averages of 21 Points (1.99 Kilometer)

CONFIDENTIAL



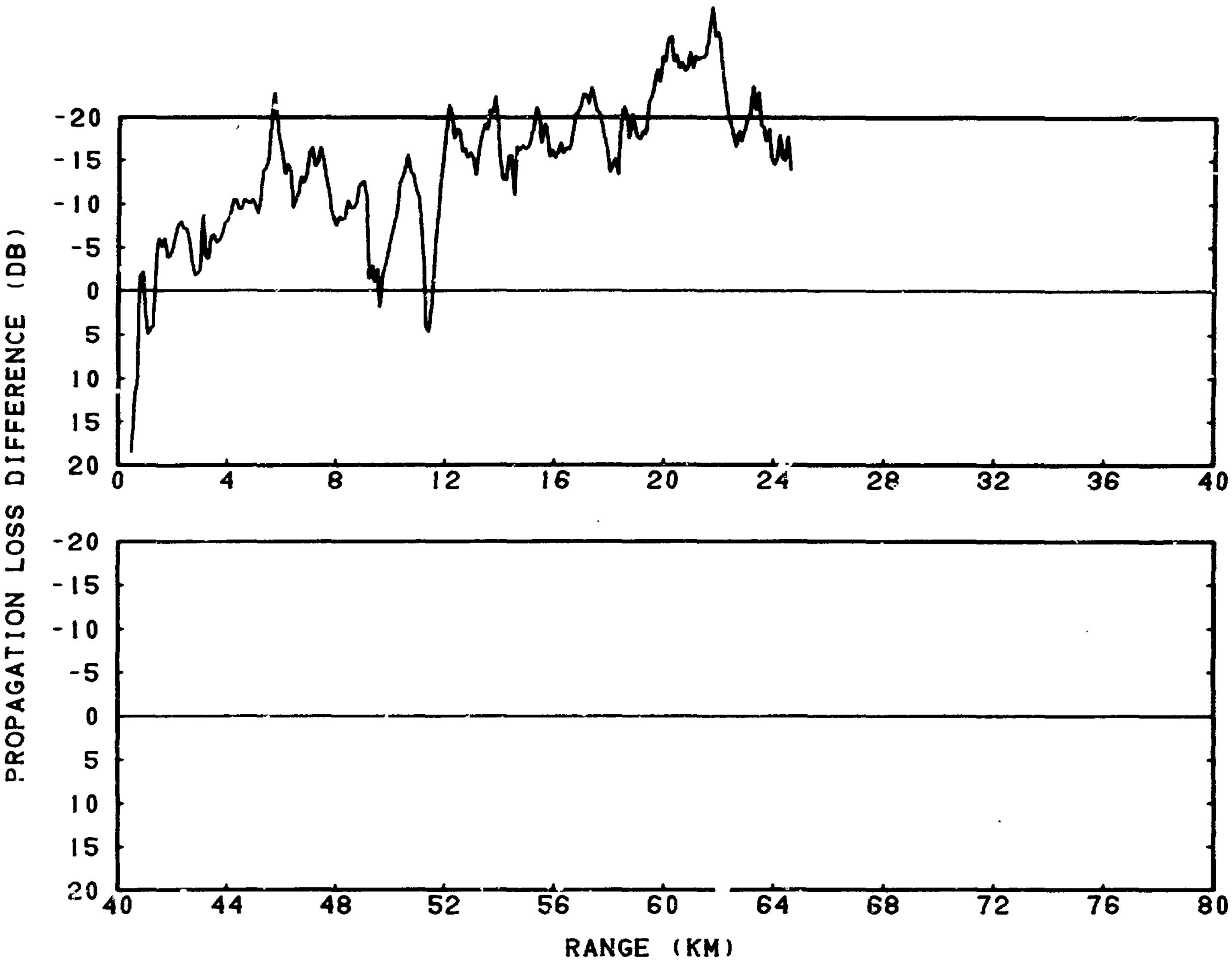
CONFIDENTIAL

(C) Figure IIIA-38. CASE V. Smocthed RAYMODE Coherent, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters, Subtracted from SUDS Data, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters



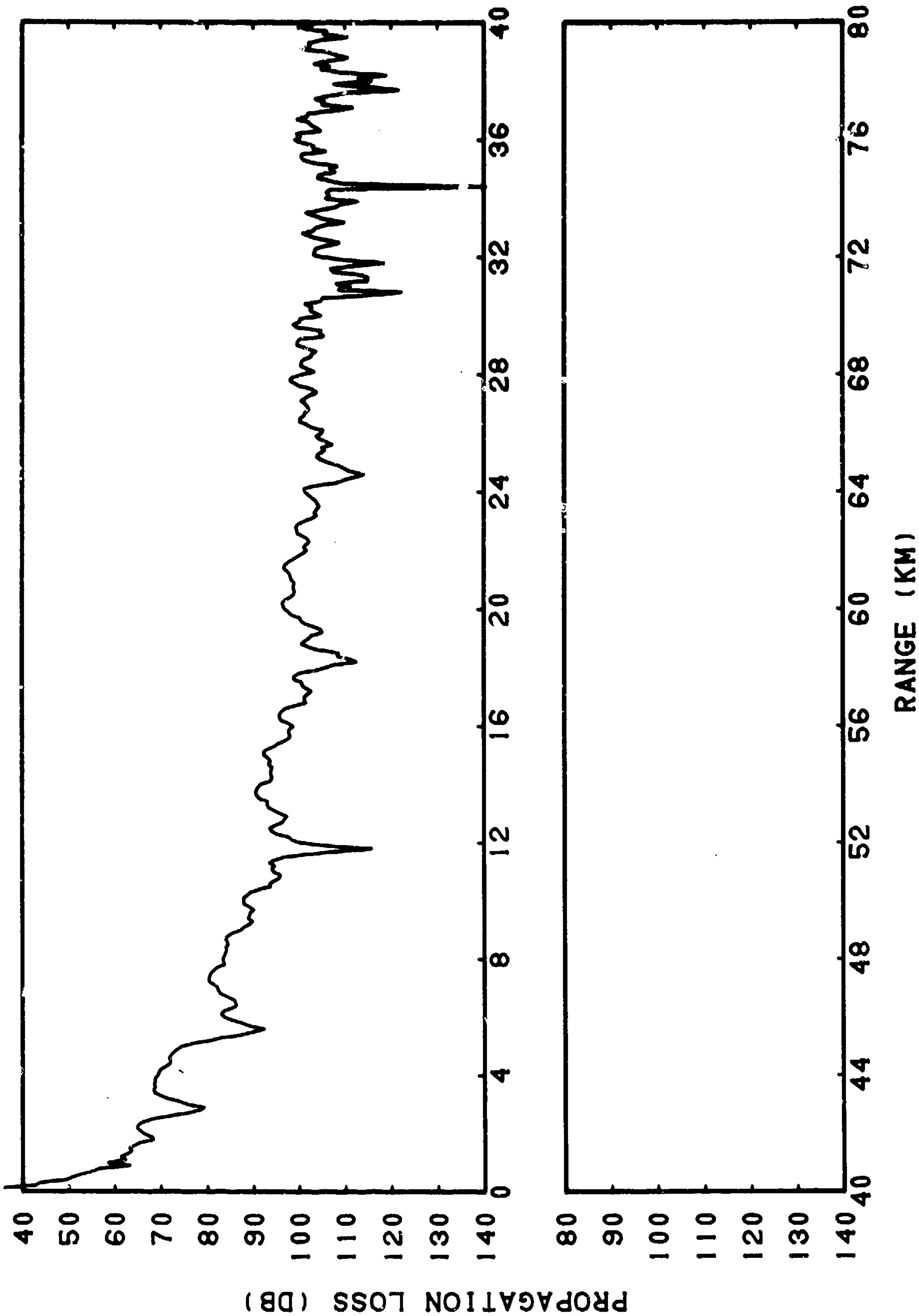
CONFIDENTIAL

(C) Figure IIIA-39. CASE V. RAYMODE Incoherent, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters



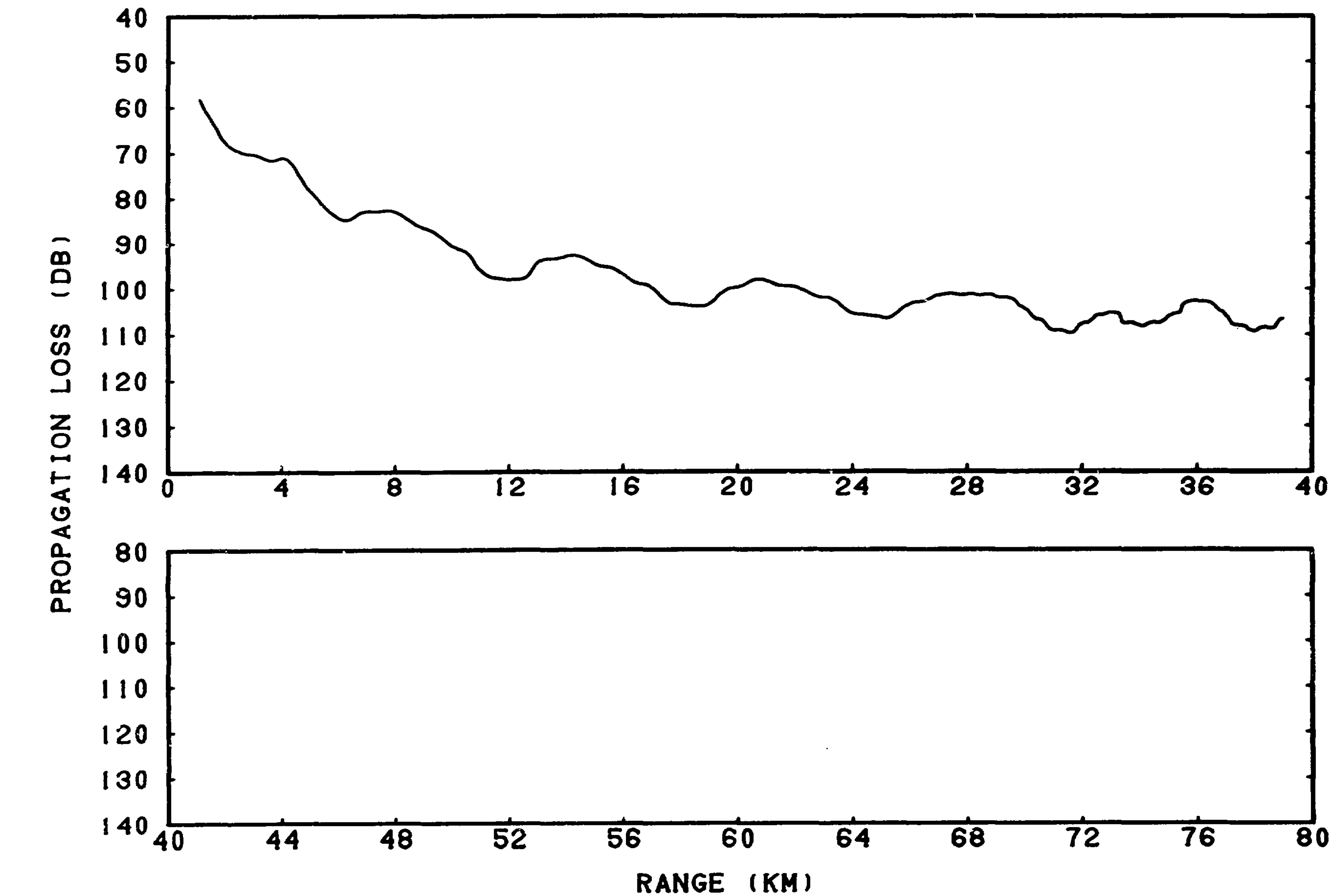
CONFIDENTIAL

(C) Figure IIIA-40. CASE V. RAYMODE Incoherent, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters, Subtracted from SUDS Data, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters



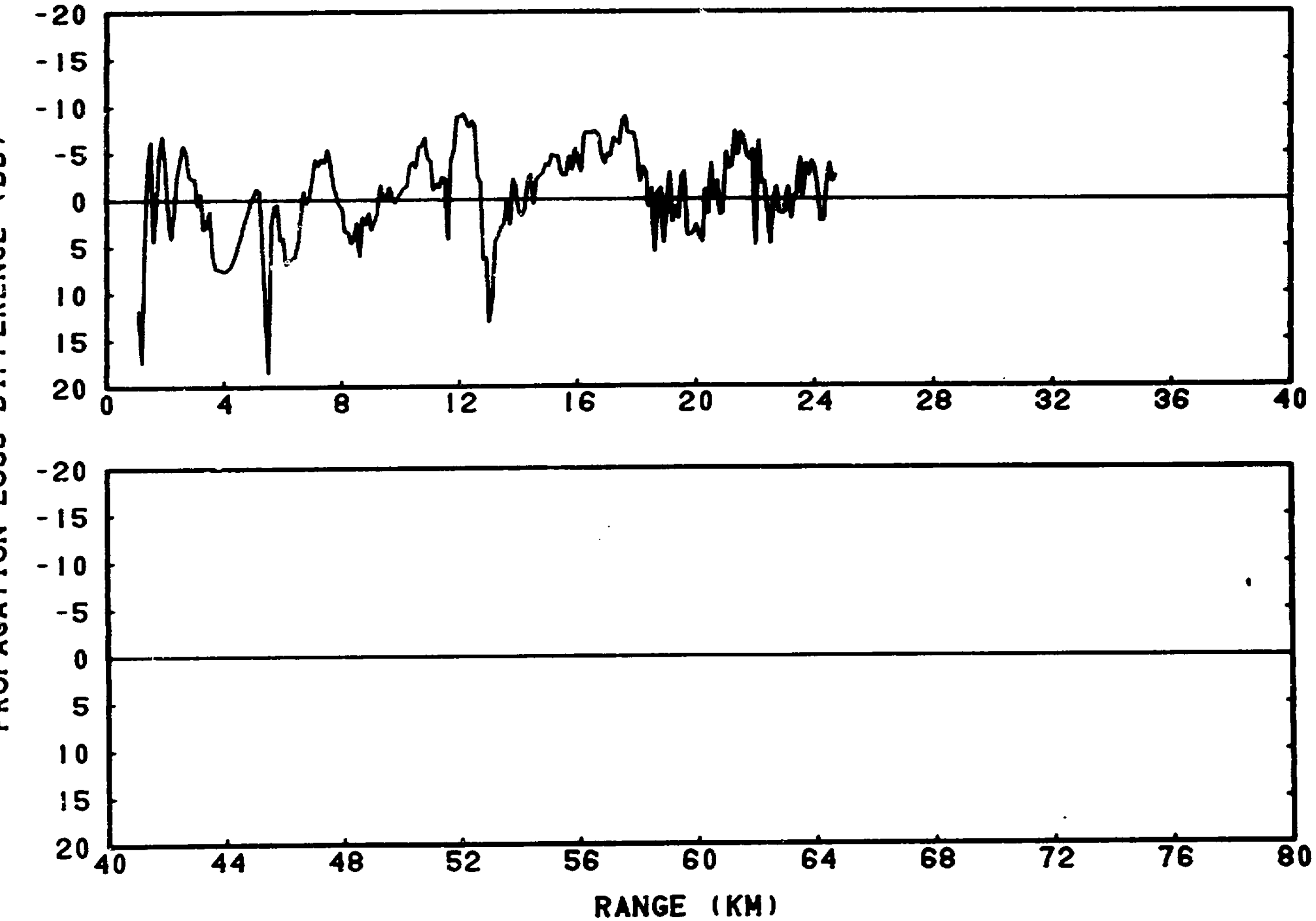
CONFIDENTIAL

(C) Figure IIIA-41. CASE VI. RAYMODE Coherent, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 69 Meters



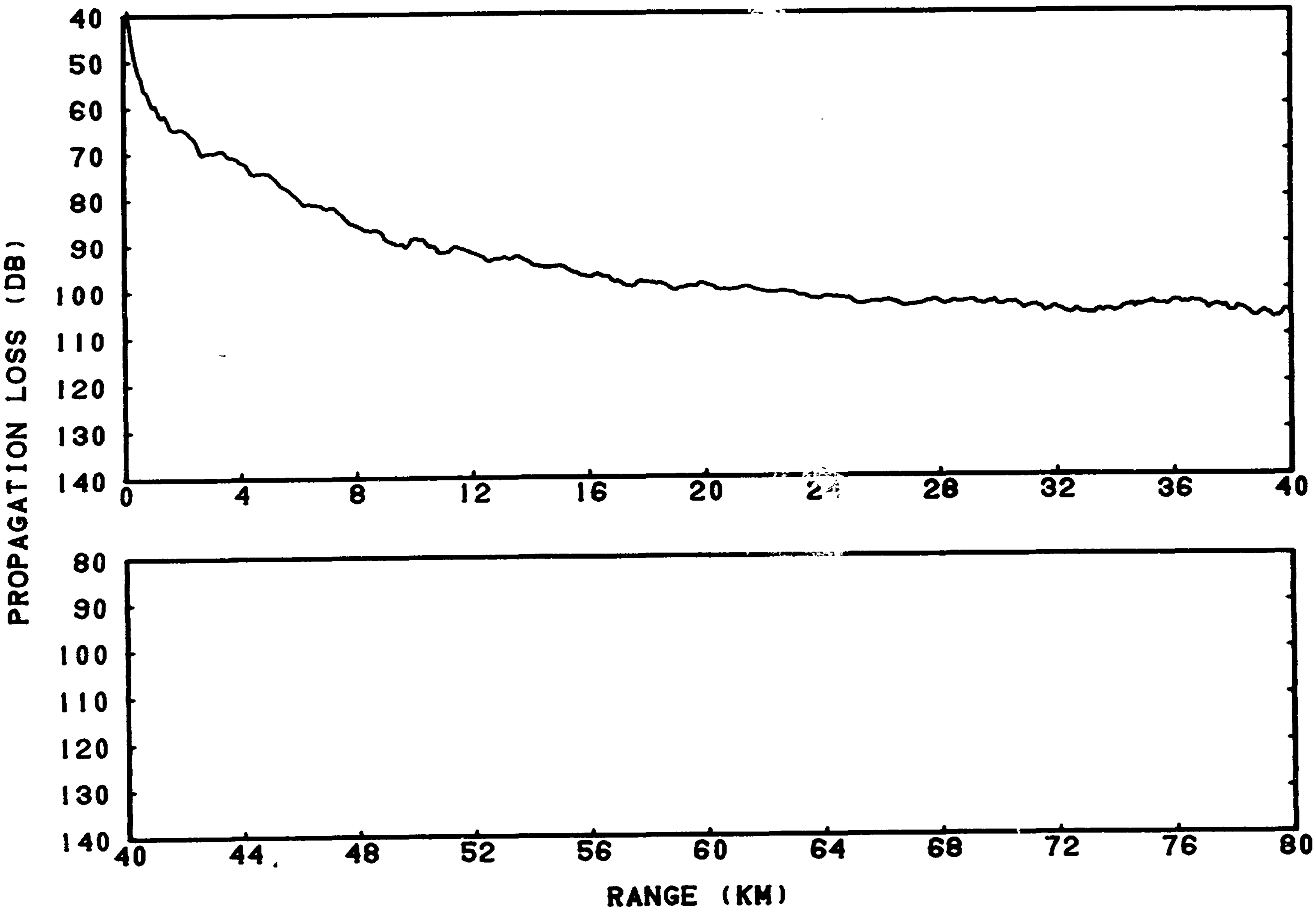
CONFIDENTIAL

(C) Figure IIIA-42. CASE VI. RAYMODE Coherent, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters, Sliding Averages of 21 Points (1.99 Kilometer)



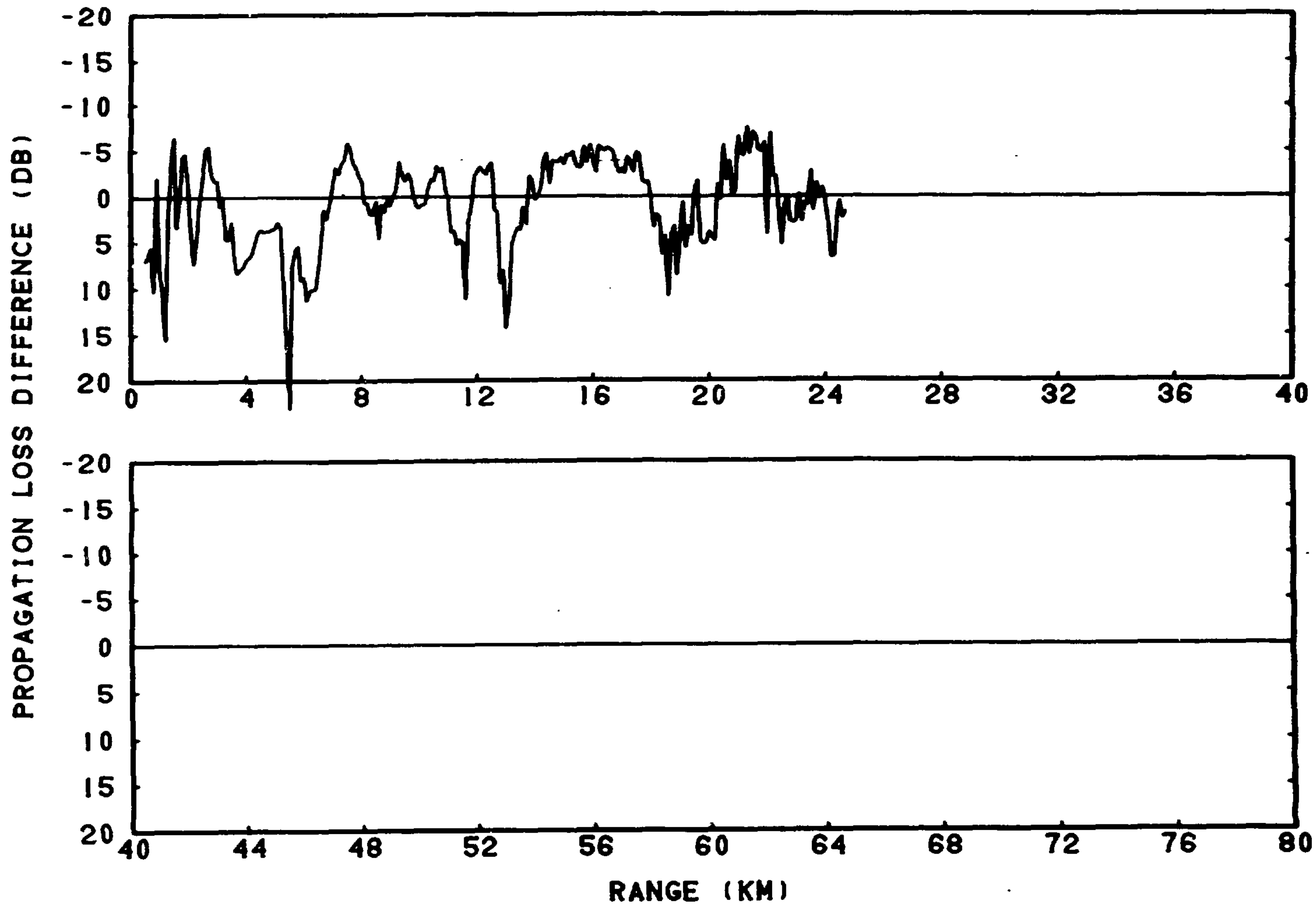
CONFIDENTIAL

(C) Figure IIIA-43. CASE VI. Smoothed RAYMODE Coherent, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters, Subtracted from SUDS Data, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters



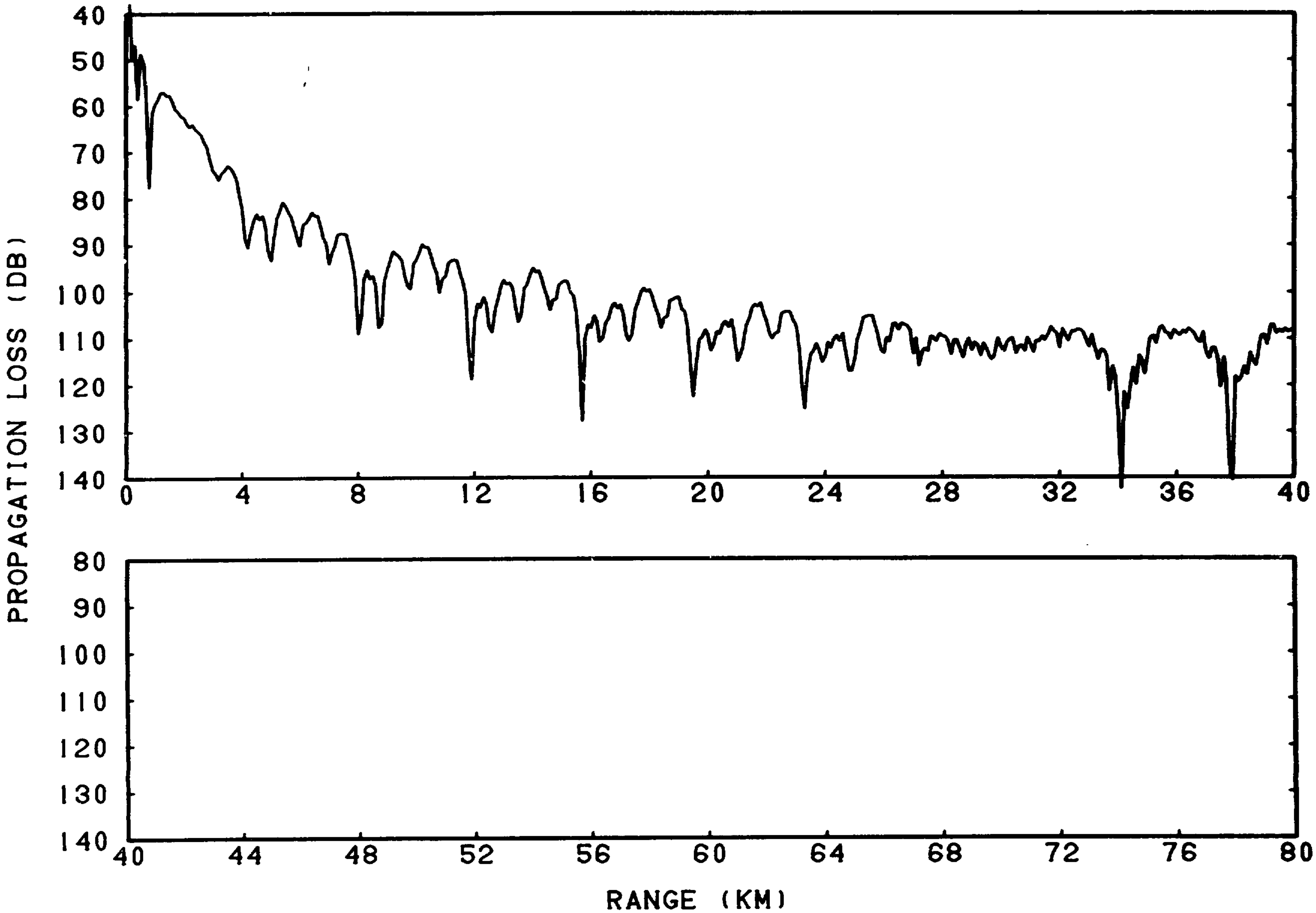
CONFIDENTIAL

(C) Figure IIIA-44. CASE VI. RAYMODE Incoherent, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters



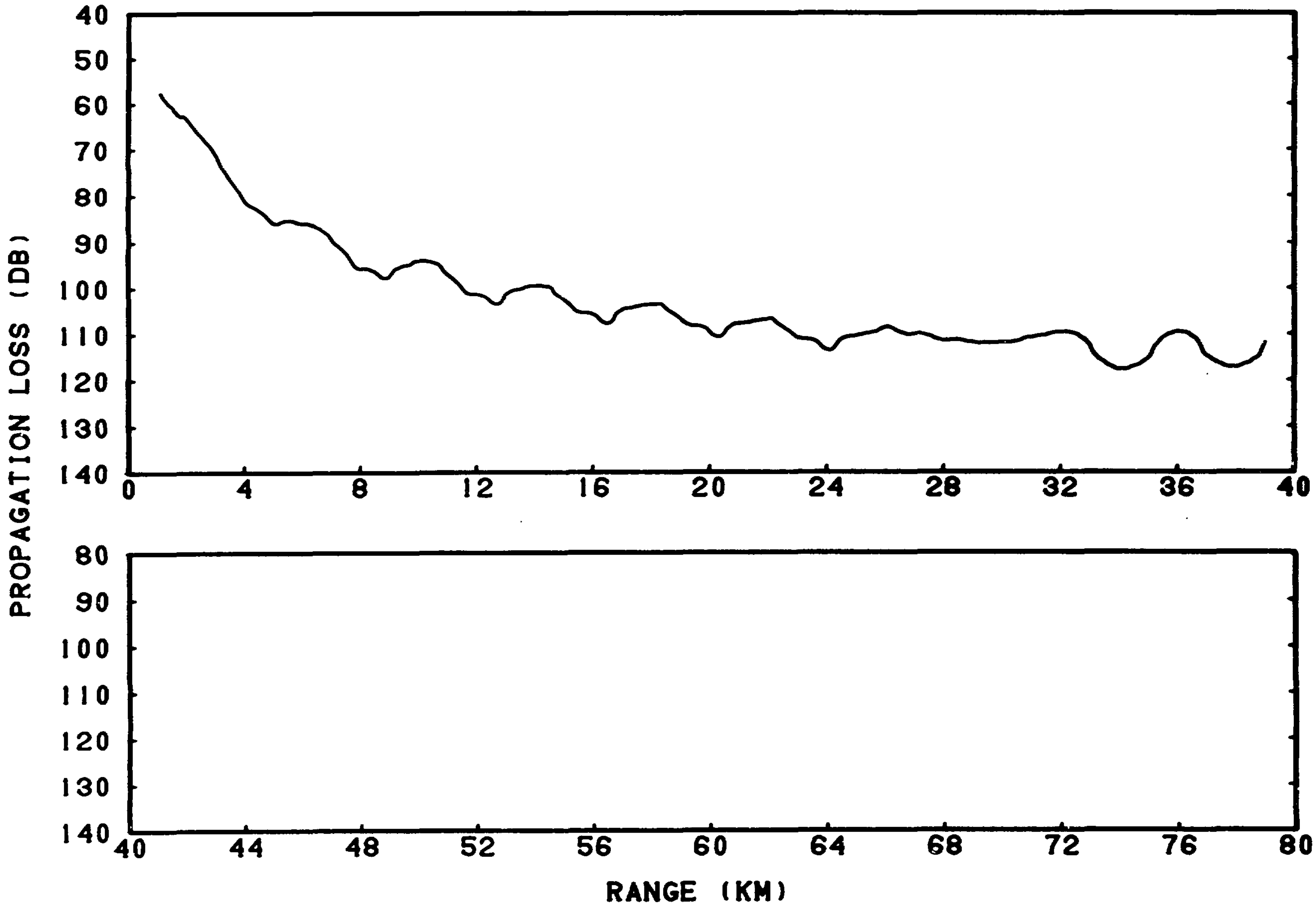
CONFIDENTIAL

(C) Figure IIIA-45. CASE VI. RAYMODE Incoherent, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters, Subtracted from SUDS Data, Frequency = 1.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters



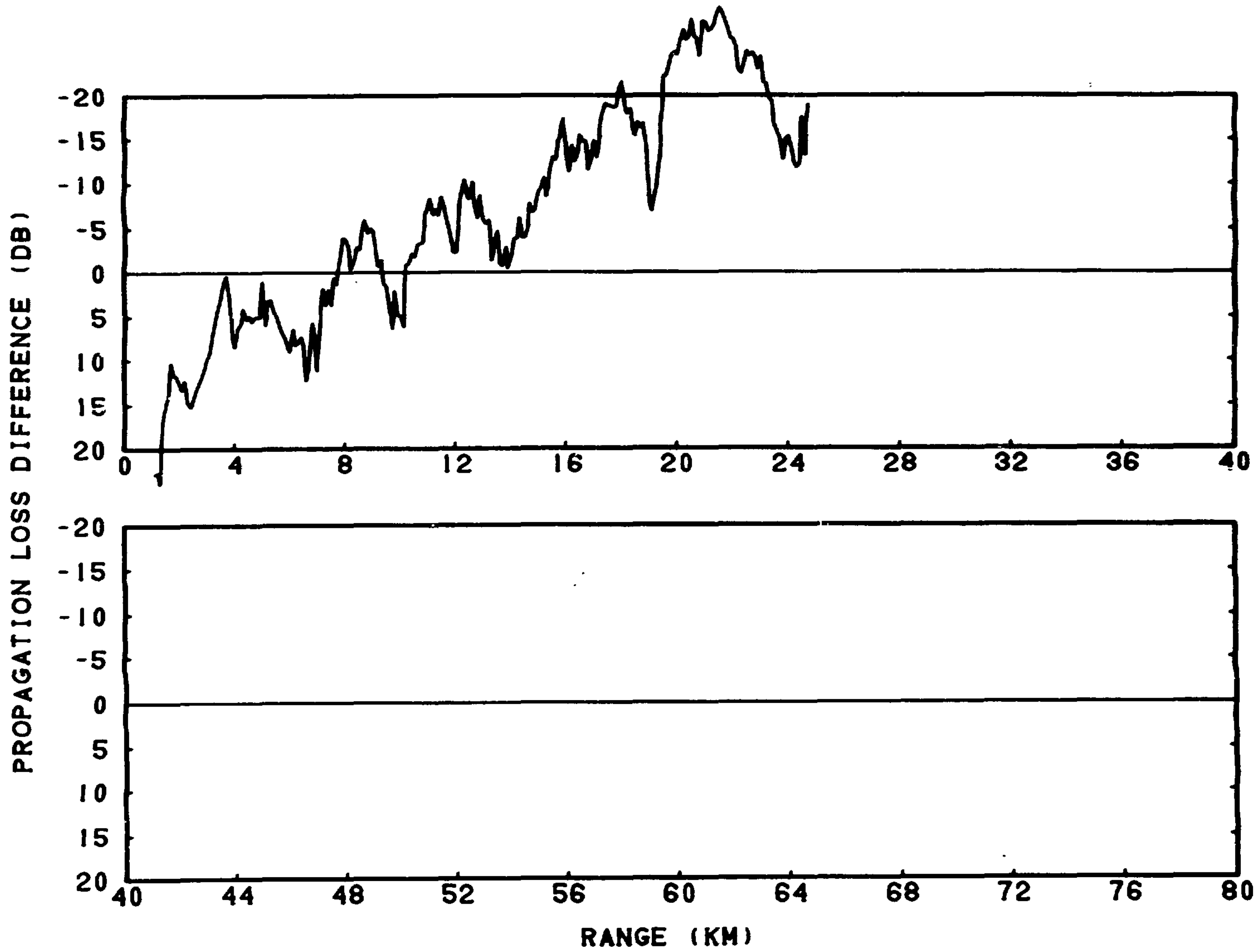
CONFIDENTIAL

(C) Figure IIIA-46. CASE VII. RAYMODE Coherent, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters



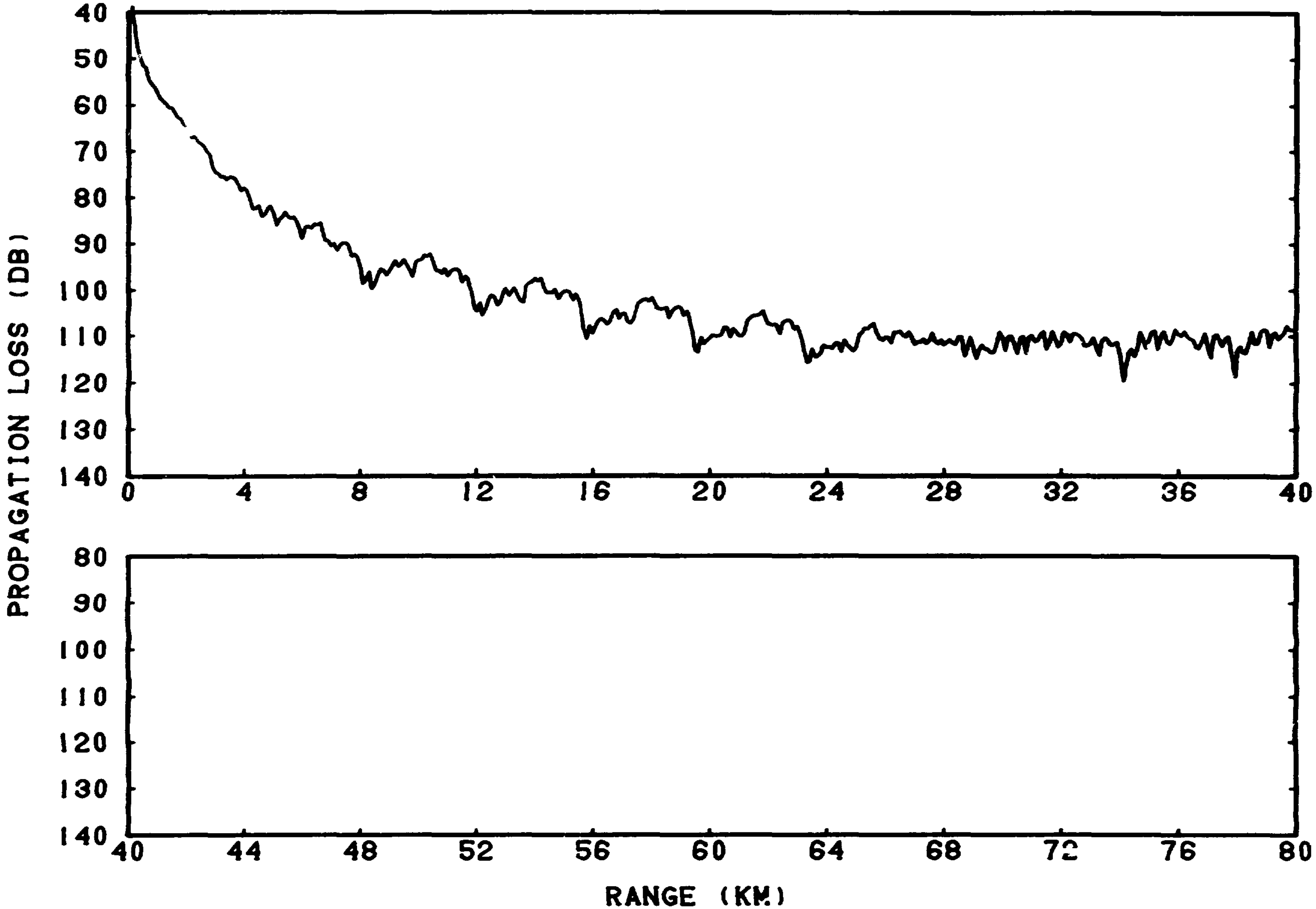
CONFIDENTIAL

(C) Figure IIIA-47. CASE VII. RAYMODE Coherent, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters, Sliding Averages of 21 Points (1.99 Kilometer)



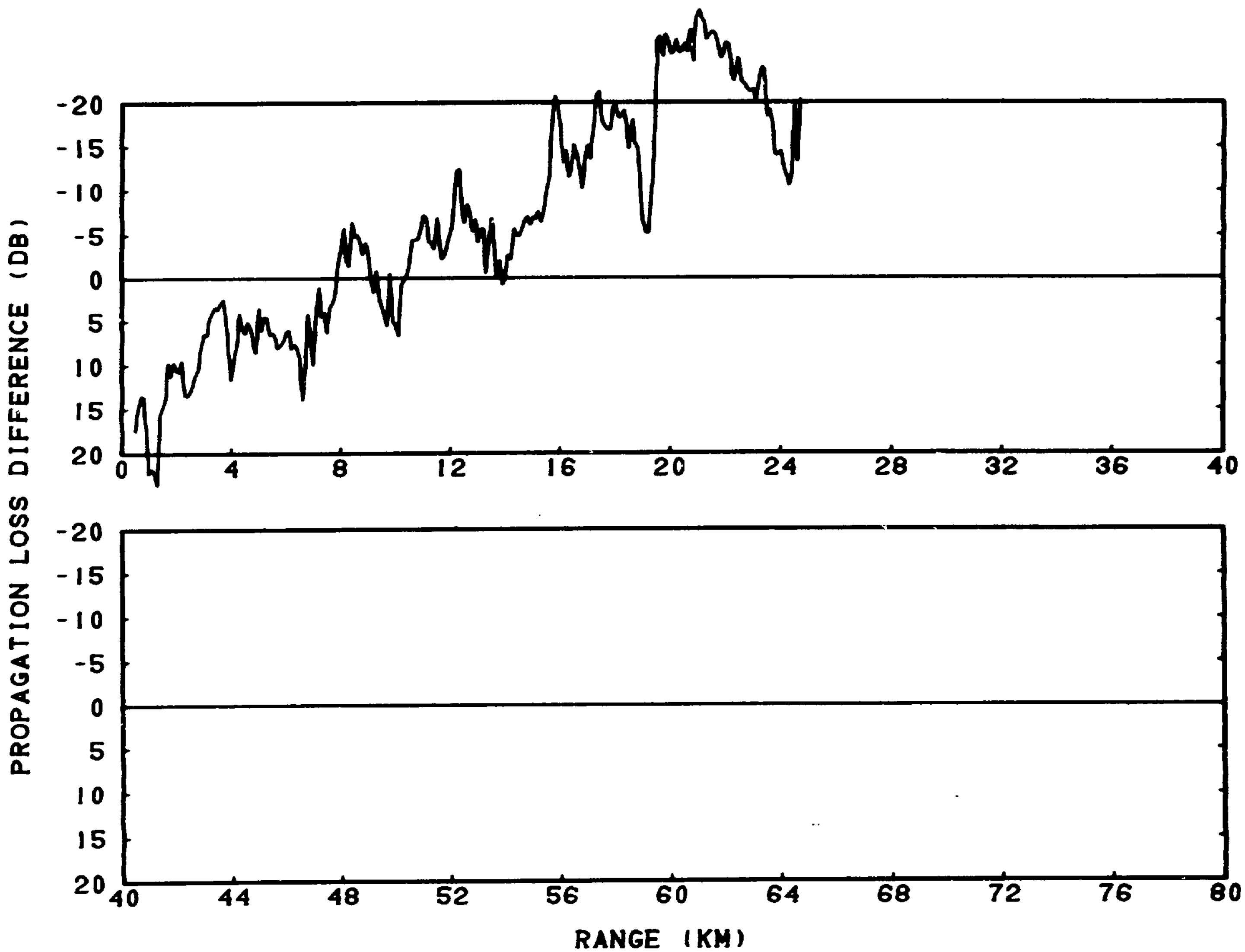
CONFIDENTIAL

(C) Figure IIIA-48. CASE VII. Smoothed RAYMODE Coherent, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters, Subtracted from SUDS Data, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters



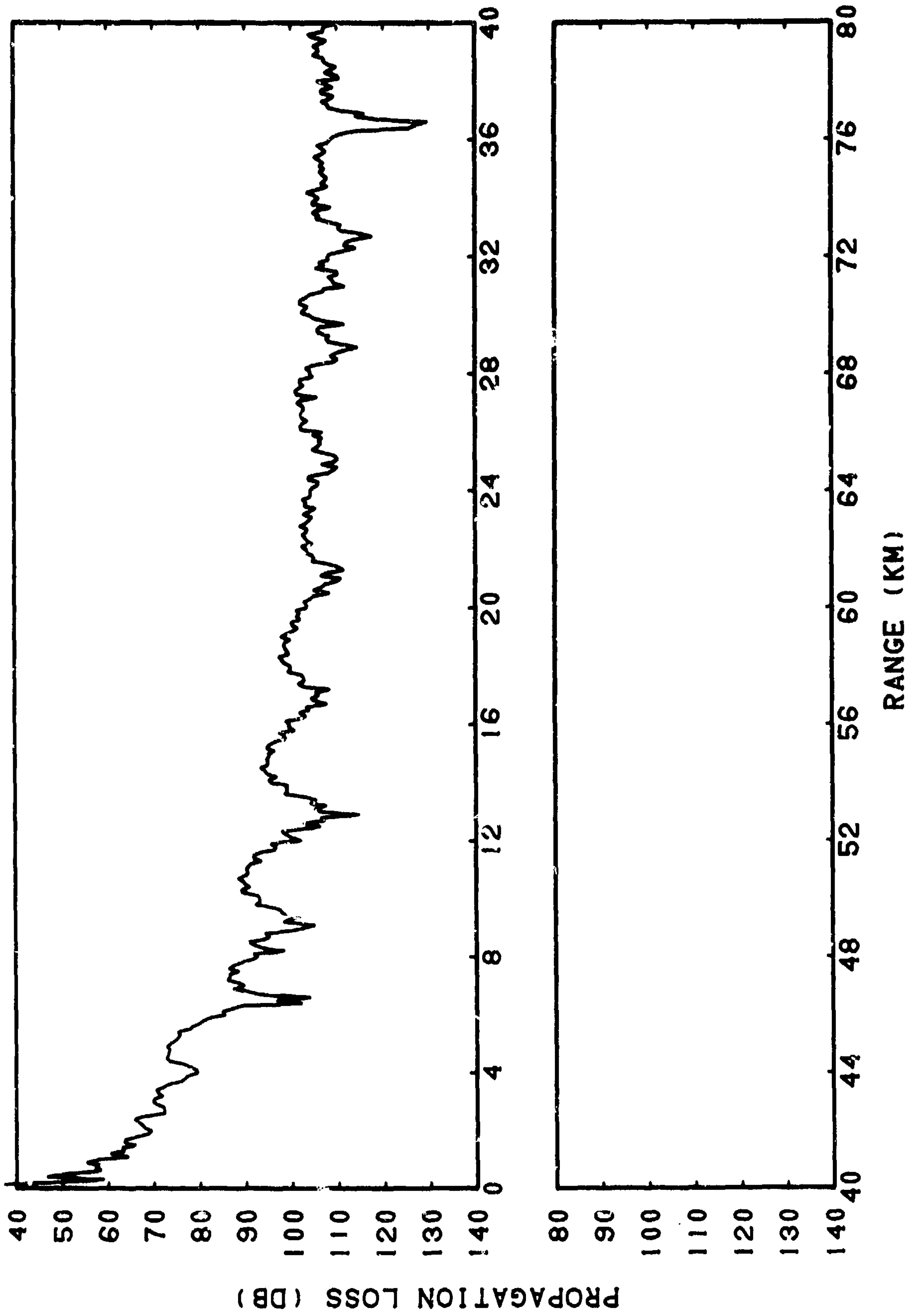
CONFIDENTIAL

(C) Figure IIIA-49. CASE VII. RAYMODE Incoherent, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters



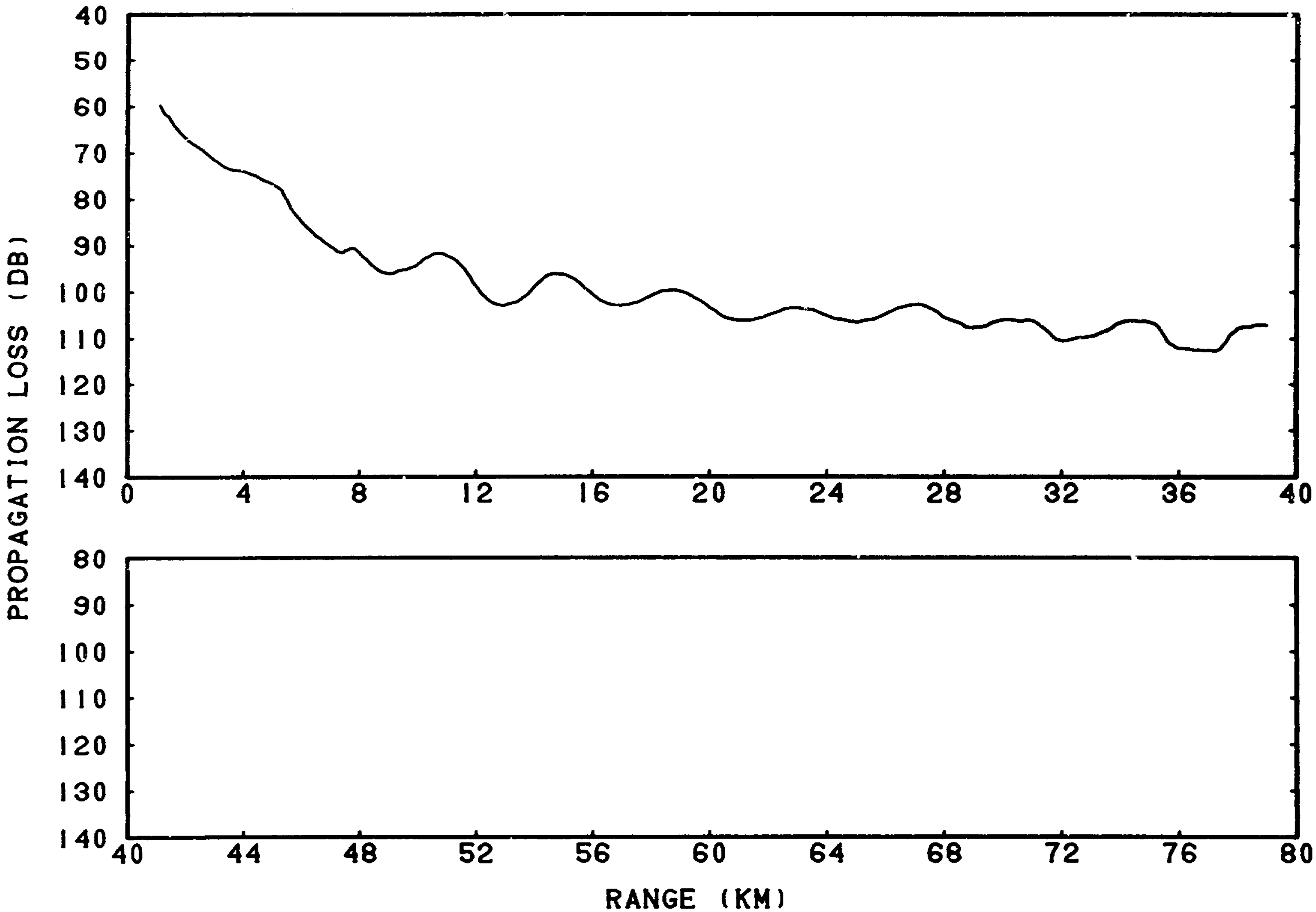
CONFIDENTIAL

(C) Figure IIIA-50. CASE VII. RAYMODE Incoherent, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters, Subtracted from SUDS Data, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 6 Meters



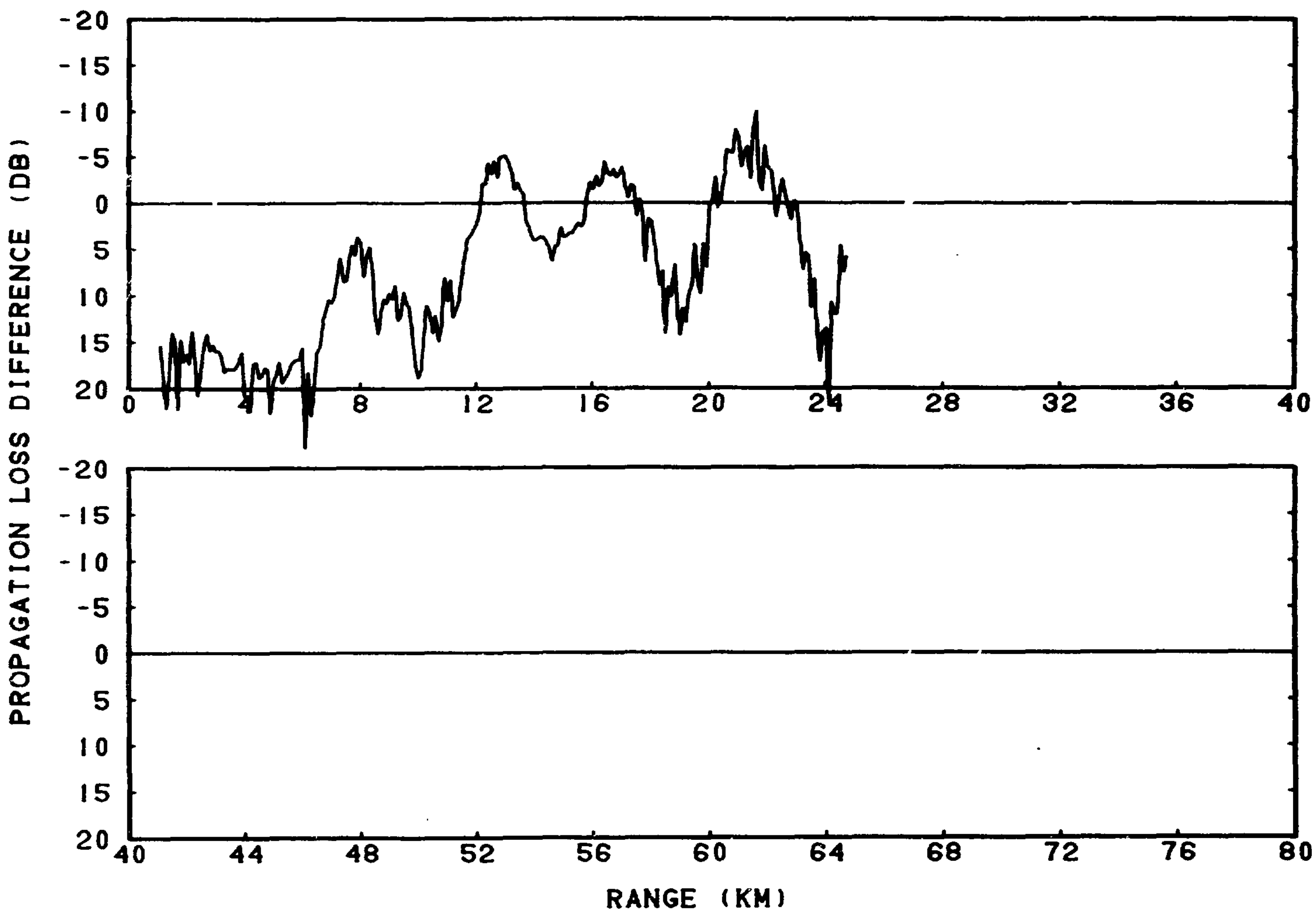
CONFIDENTIAL

(C) Figure IIIA-51. CASE VIII. RAYMODE Coherent, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters



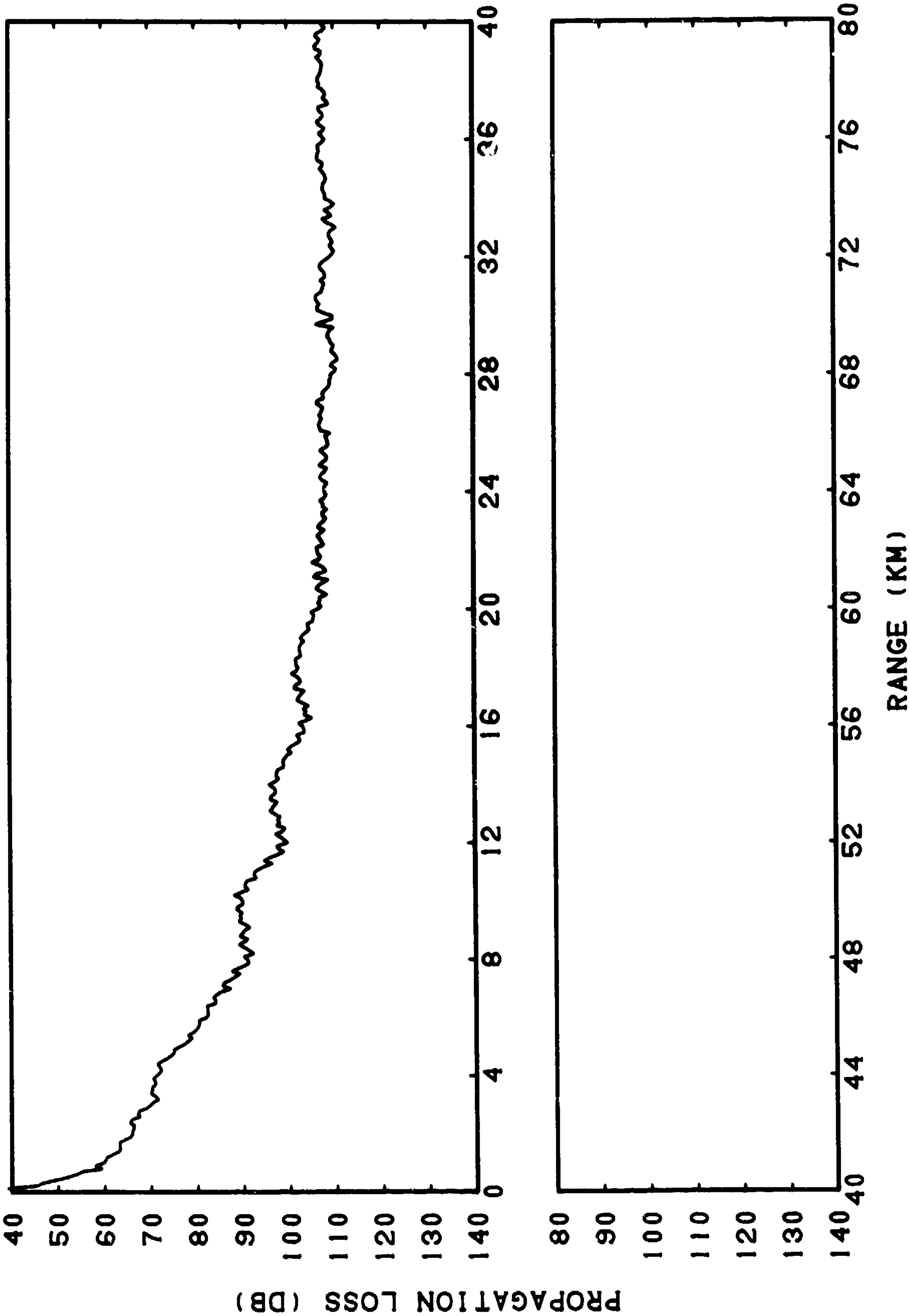
CONFIDENTIAL

(C) Figure IIIA-52. CASE VIII. RAYMODE Coherent, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters, Sliding Averages of 21 Points (1.99 Kilometer)



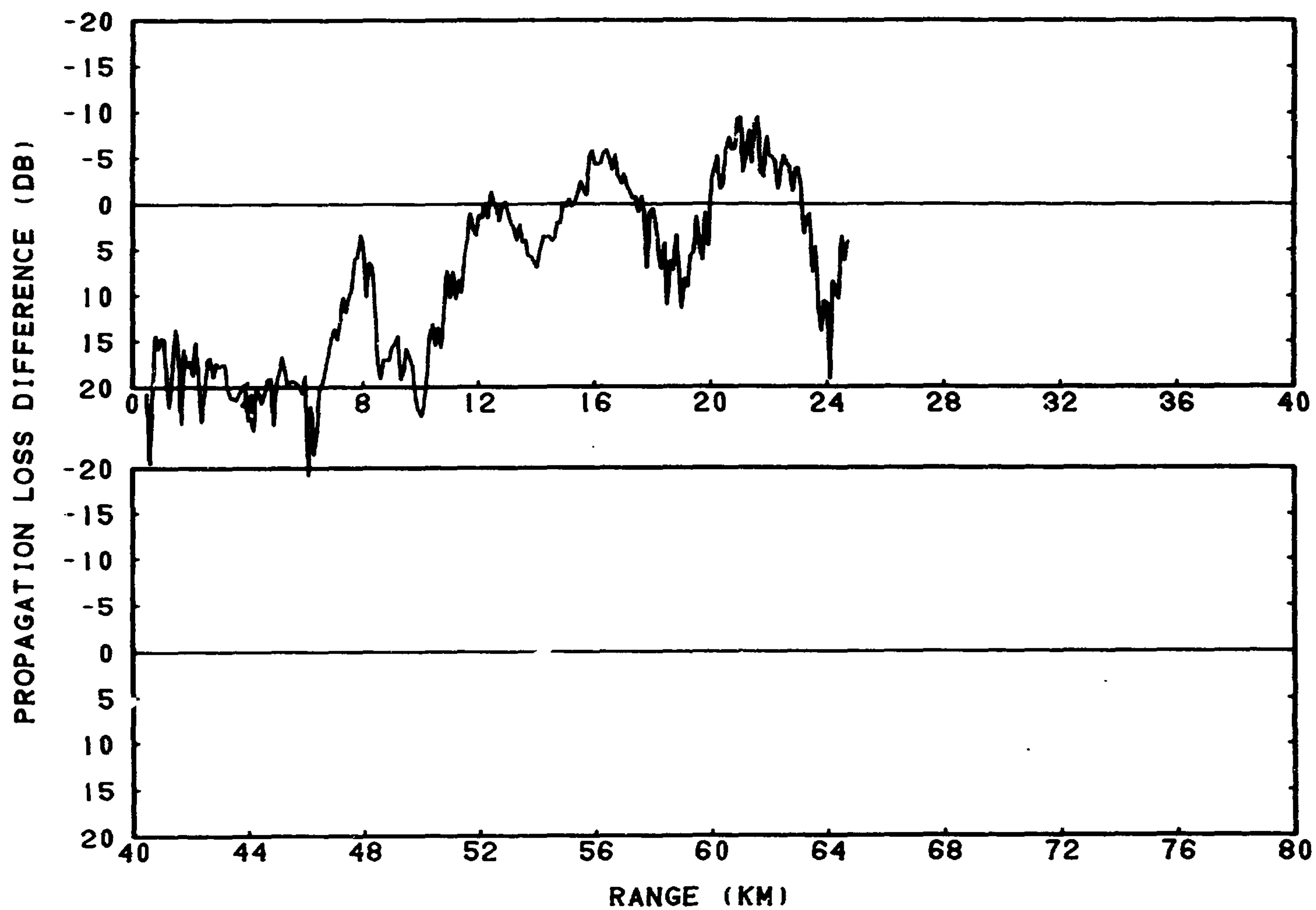
CONFIDENTIAL

(C) Figure IIIA-53. CASE VIII. Smoothed RAYMODE Coherent, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters, Subtracted from SUDS Data, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters



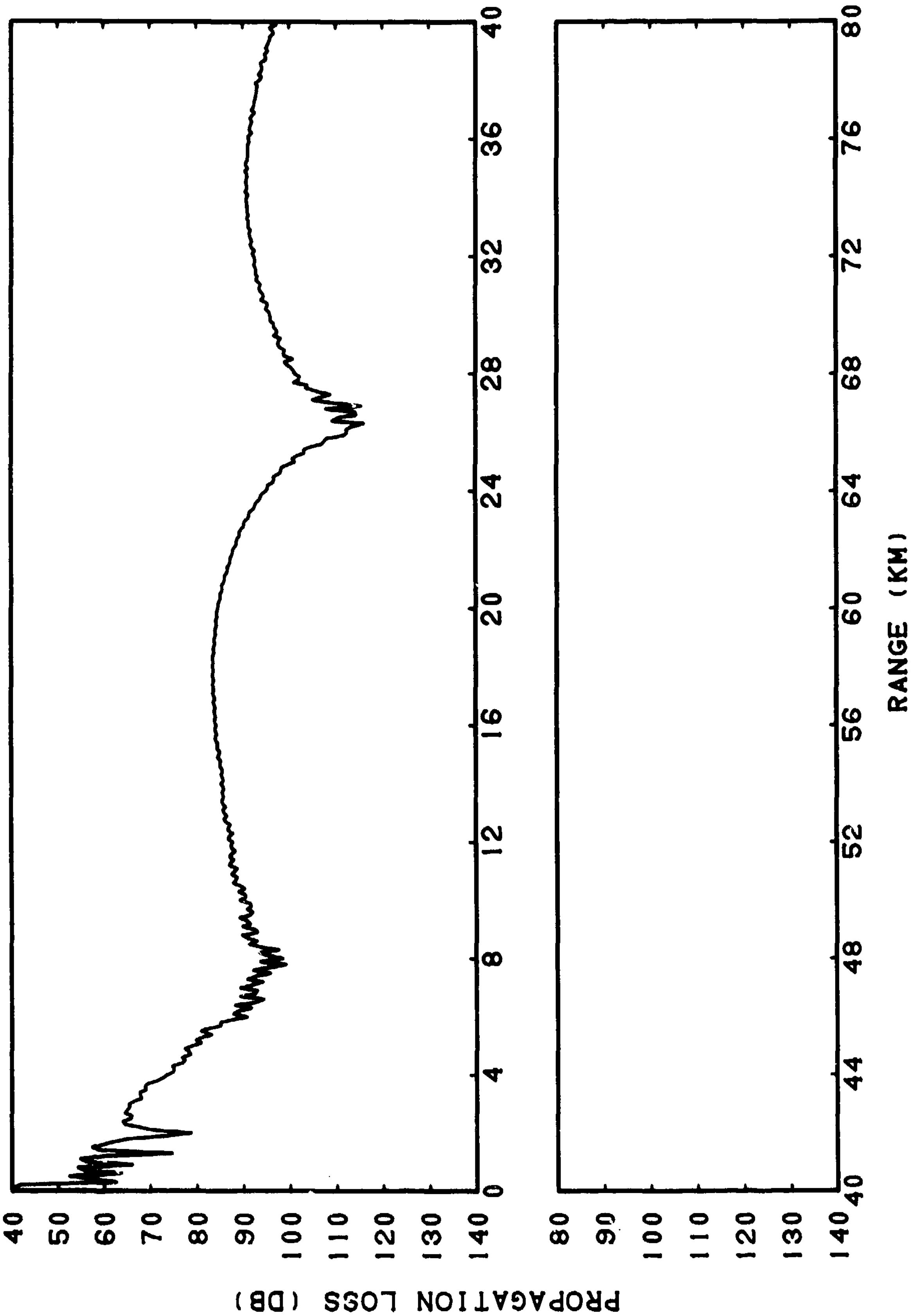
CONFIDENTIAL

(C) Figure IIIA-54. CASE VIII. RAYMODE Incoherent, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters



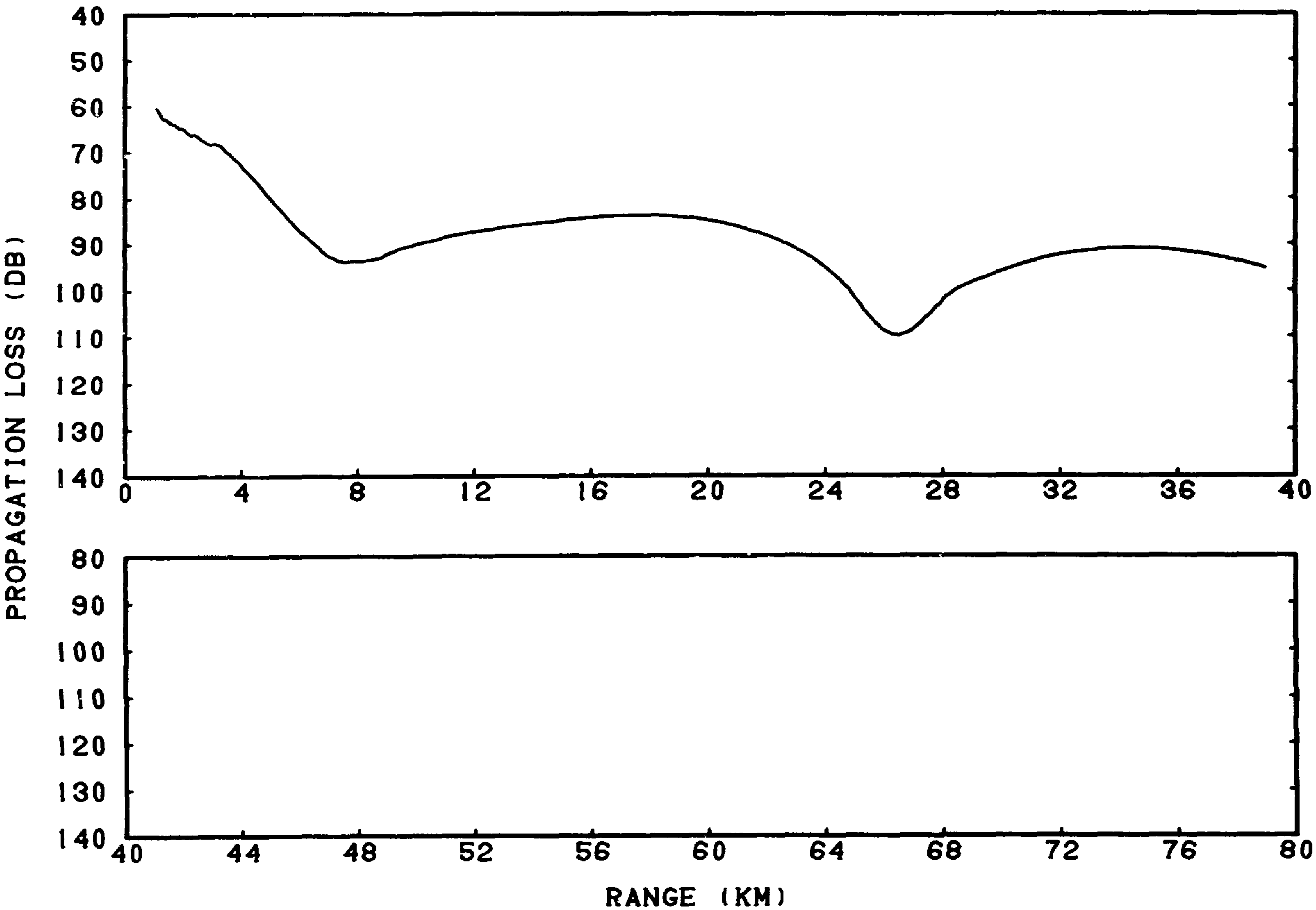
CONFIDENTIAL

(C) Figure IIIA-55. CASE VIII. RAYMODE Incoherent, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters, Subtracted from SUDS Data, Frequency = 2.5 Kilohertz, Source Depth = 41 Meters, Receiver Depth = 59 Meters



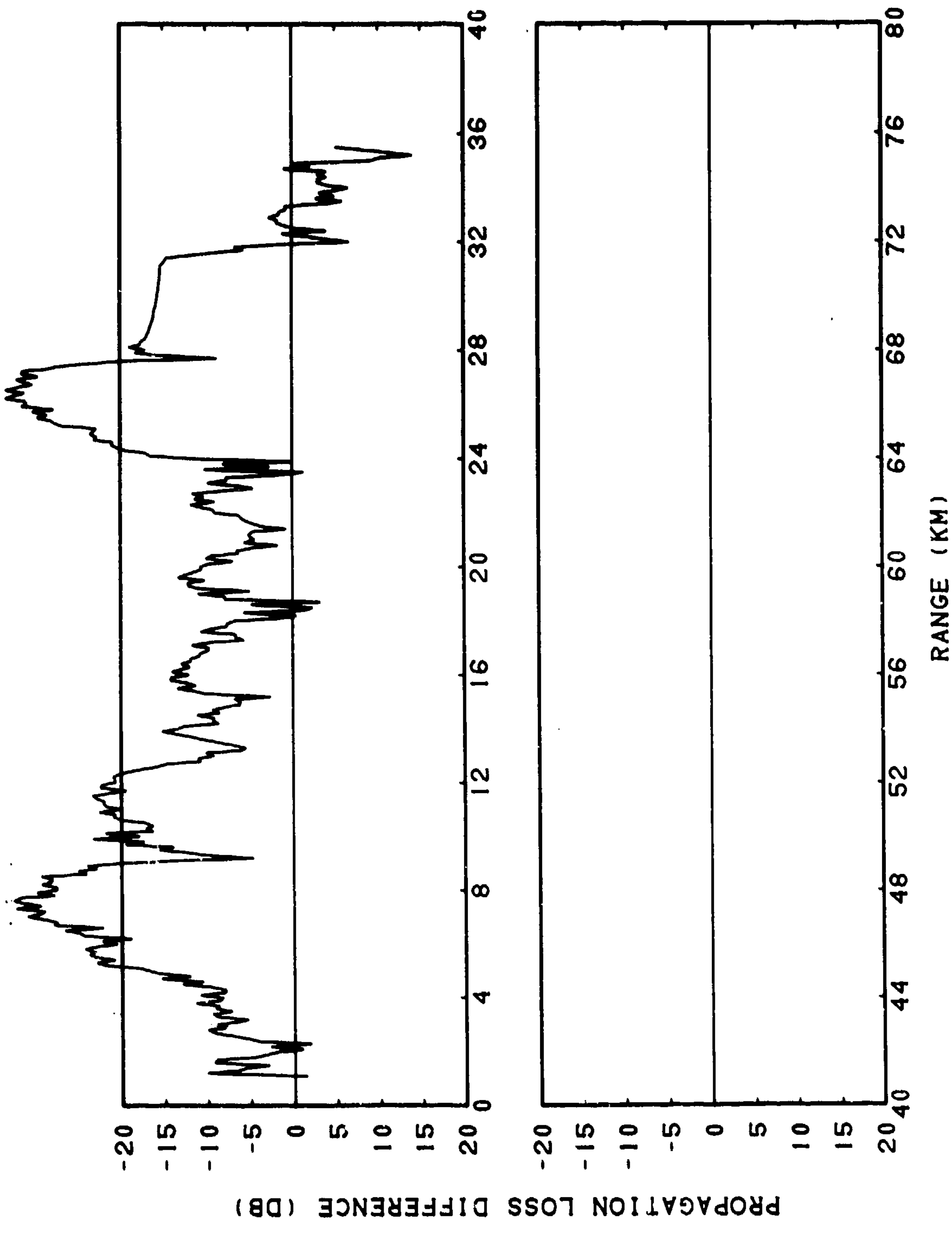
CONFIDENTIAL

(C) Figure IIIA-56. CASE IX. RAYMODE Coherent, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters



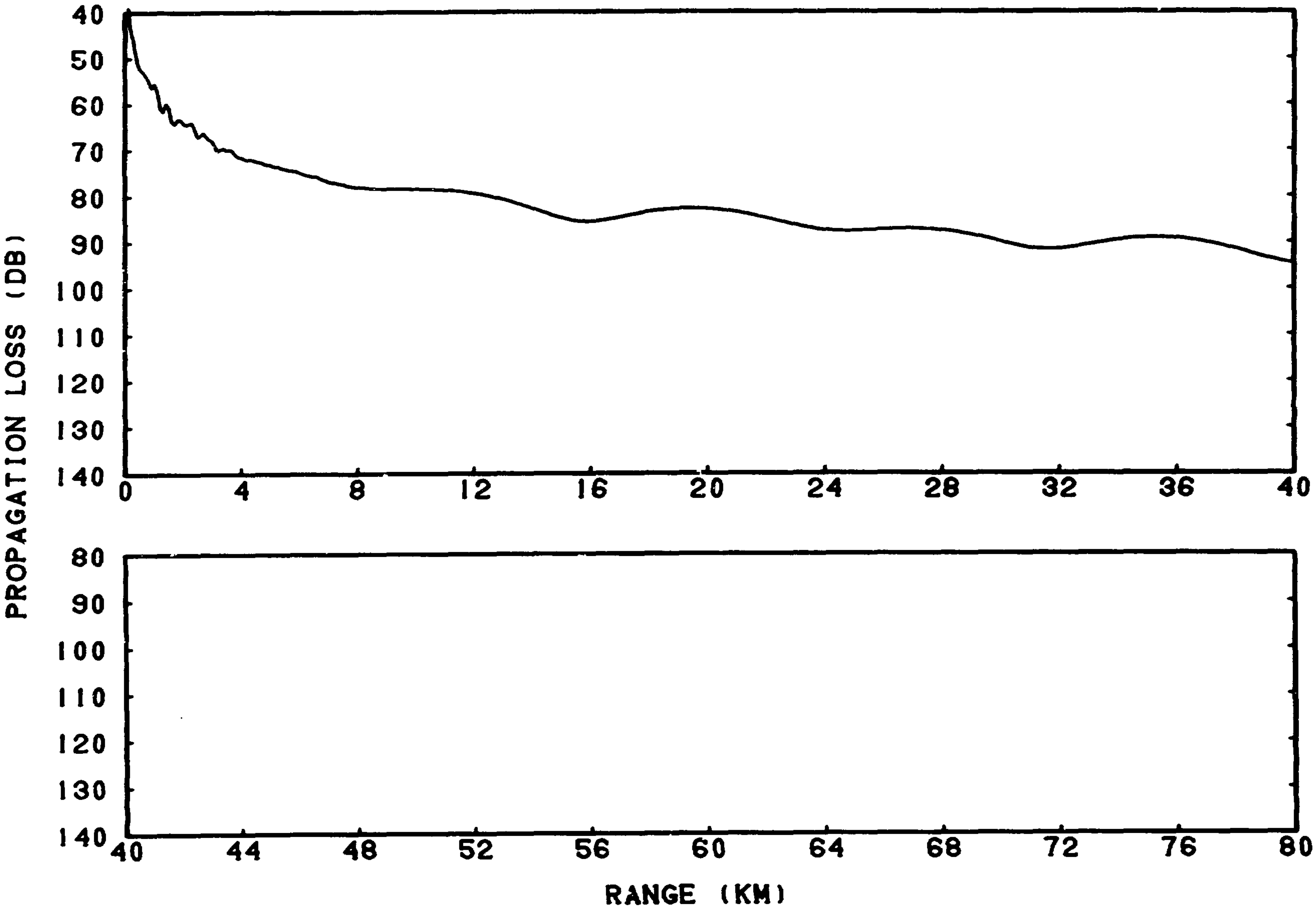
CONFIDENTIAL

(C) Figure IIIA-57. CASE IX. RAYMODE Coherent, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters, Sliding Averages of 21 Points (1.99 Kilometer)



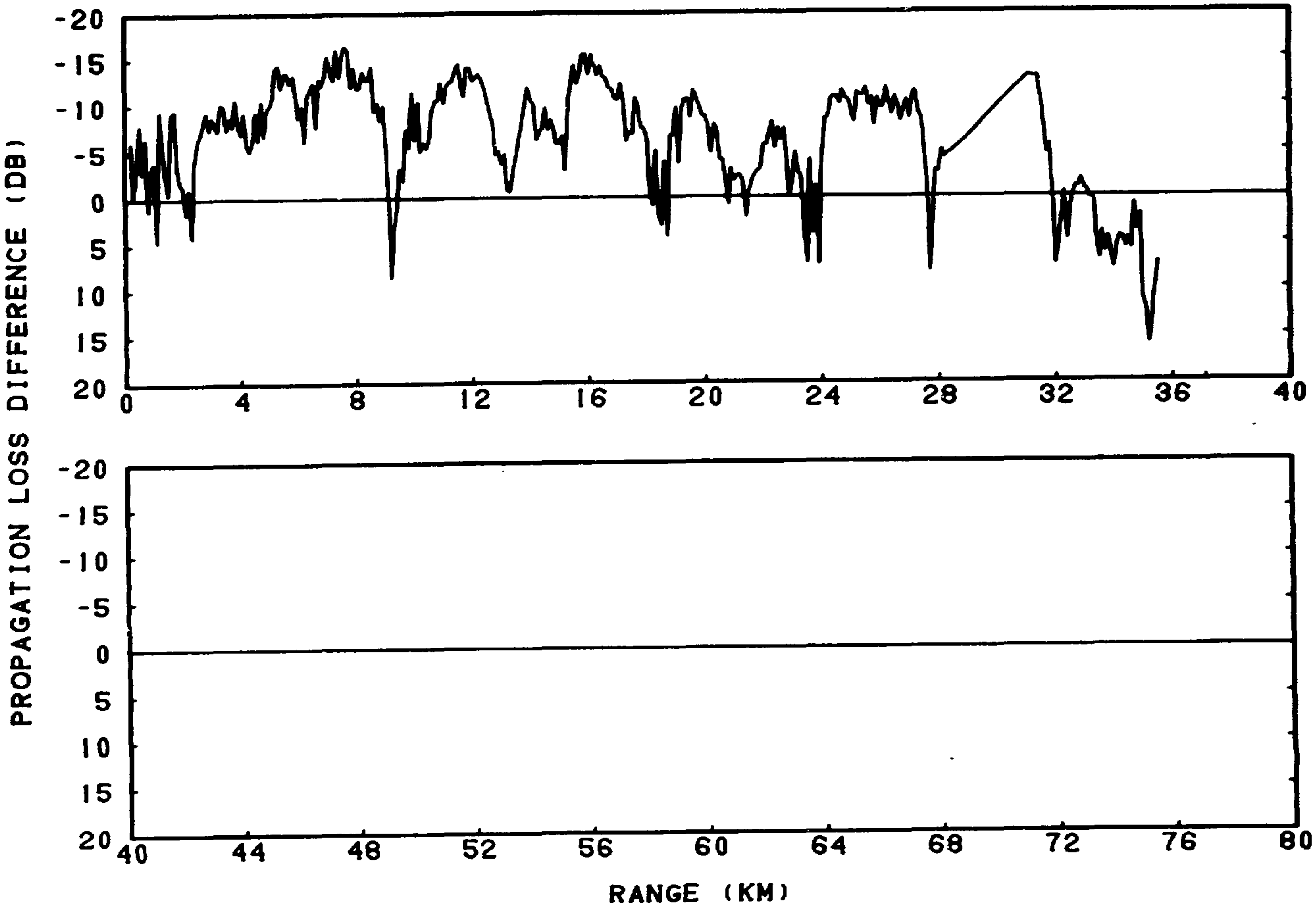
CONFIDENTIAL

(C) Figure IIIA-58. CASE IX. Smoothed RAYMODE Coherent, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters, Subtracted from SUDS Data, Frequency = 3.5 Meters, Source Depth = 45 Meters, Receiver Depth = 17 Meters



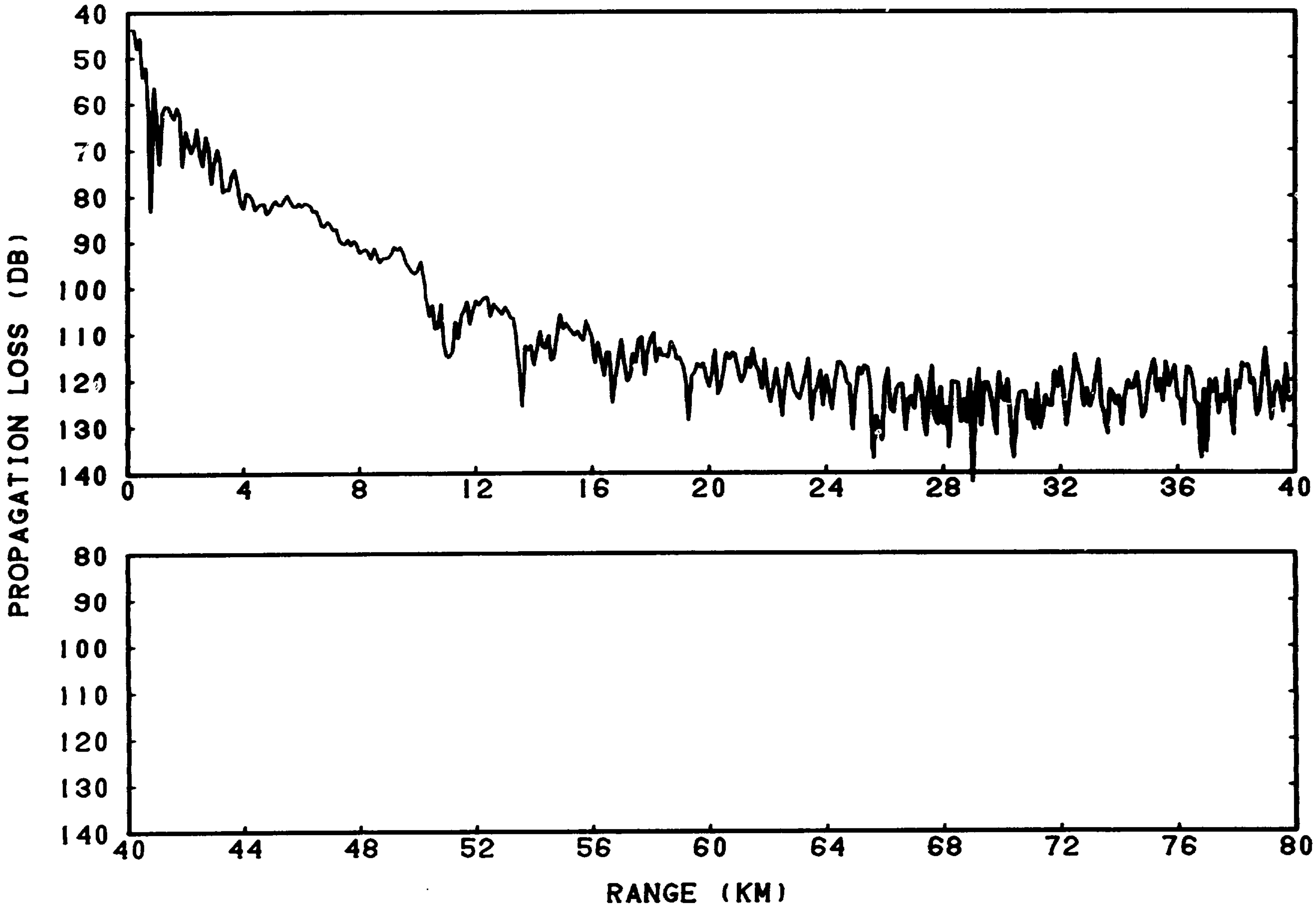
CONFIDENTIAL

(C) Figure IIIA-59. CASE IX. RAYMODE Incoherent, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters



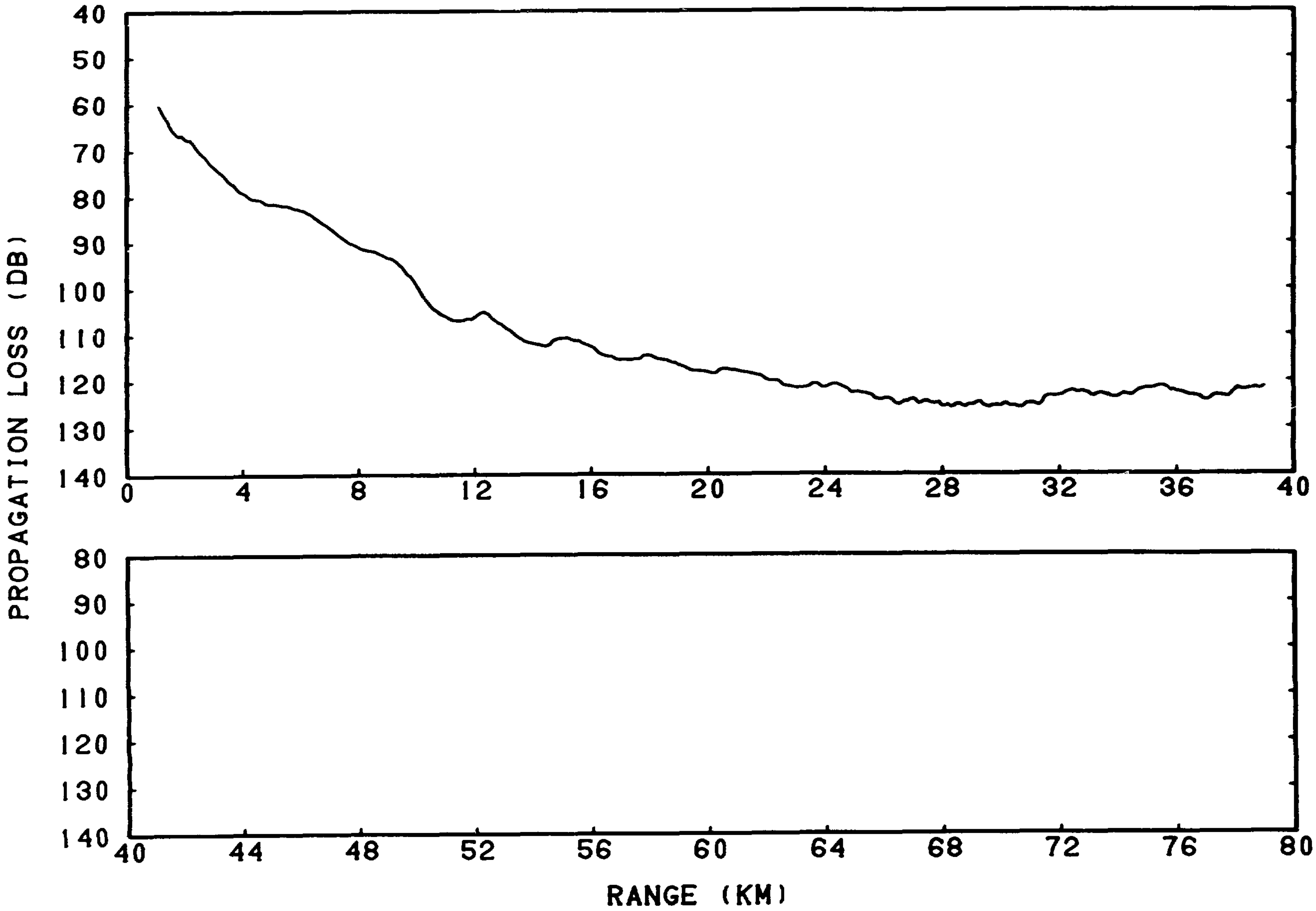
CONFIDENTIAL

(C) Figure IIIA-60. CASE IX. RAYMODE Incoherent, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters, Subtracted from SUDS Data, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 17 Meters



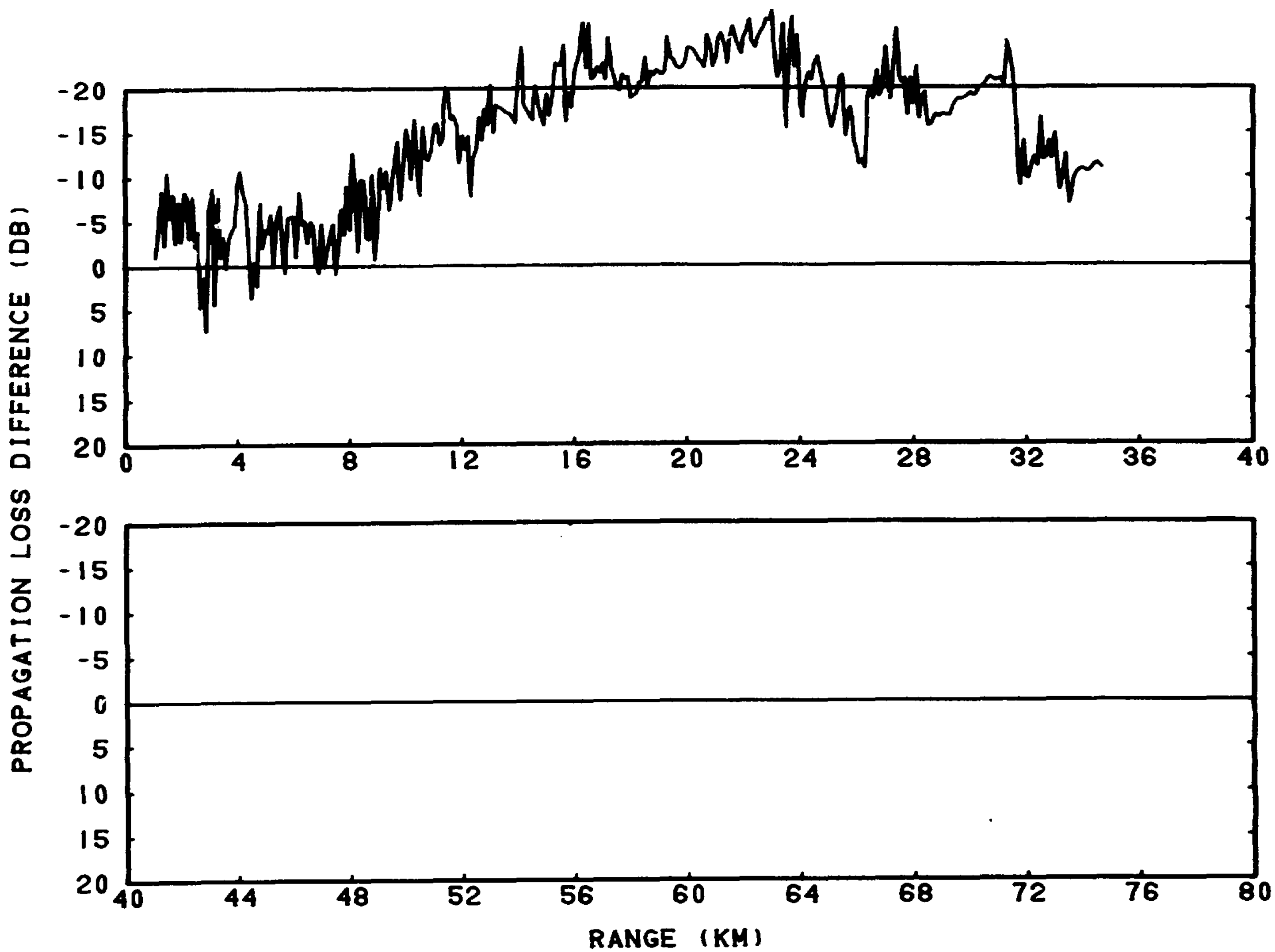
CONFIDENTIAL

(C) Figure IIIA-61. CASE X. RAYMODE Coherent, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters



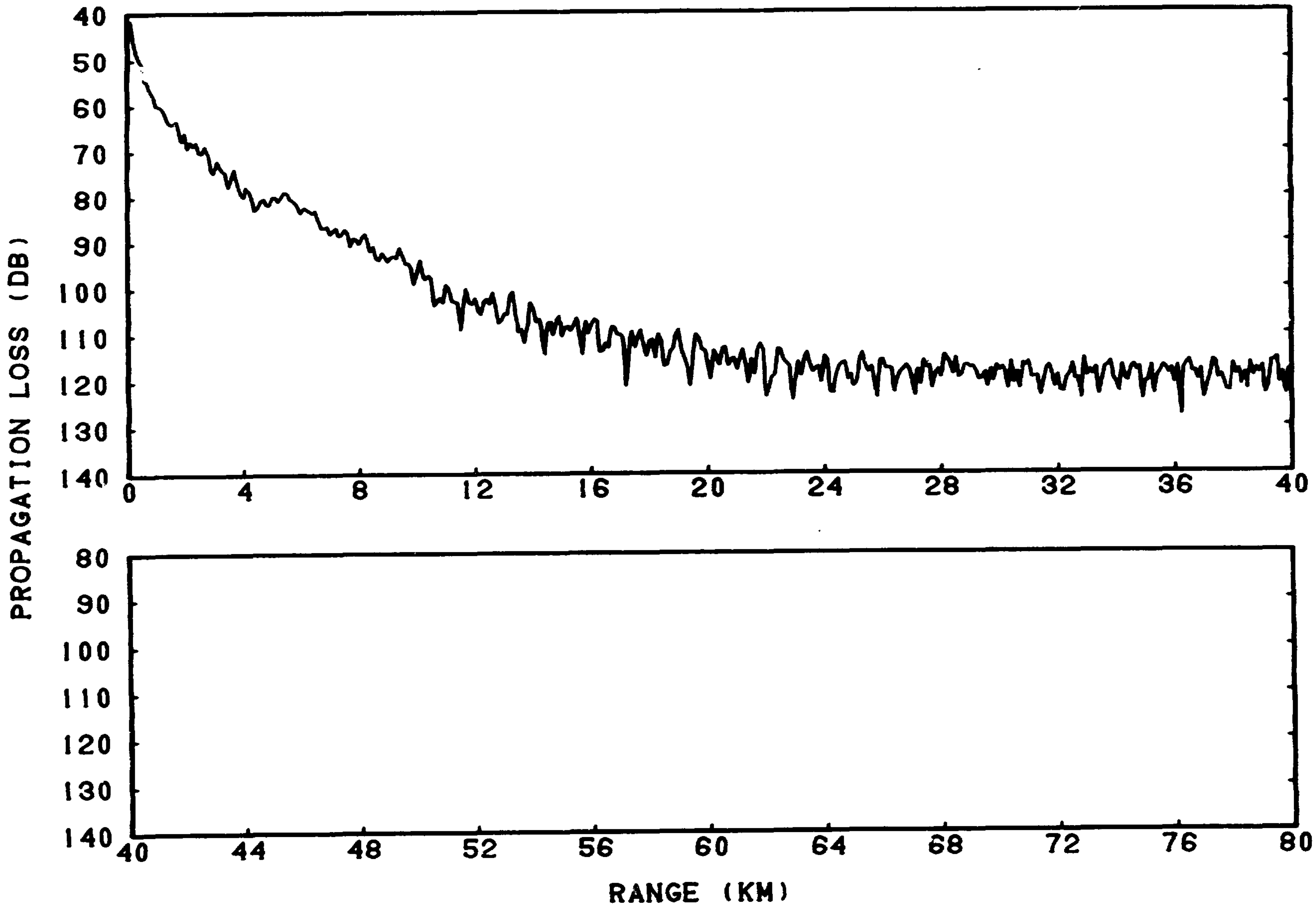
CONFIDENTIAL

(C) Figure IIIA-62. CASE X. RAYMODE Coherent, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters, Sliding Averages of 21 Points (1.99 Kilometer)



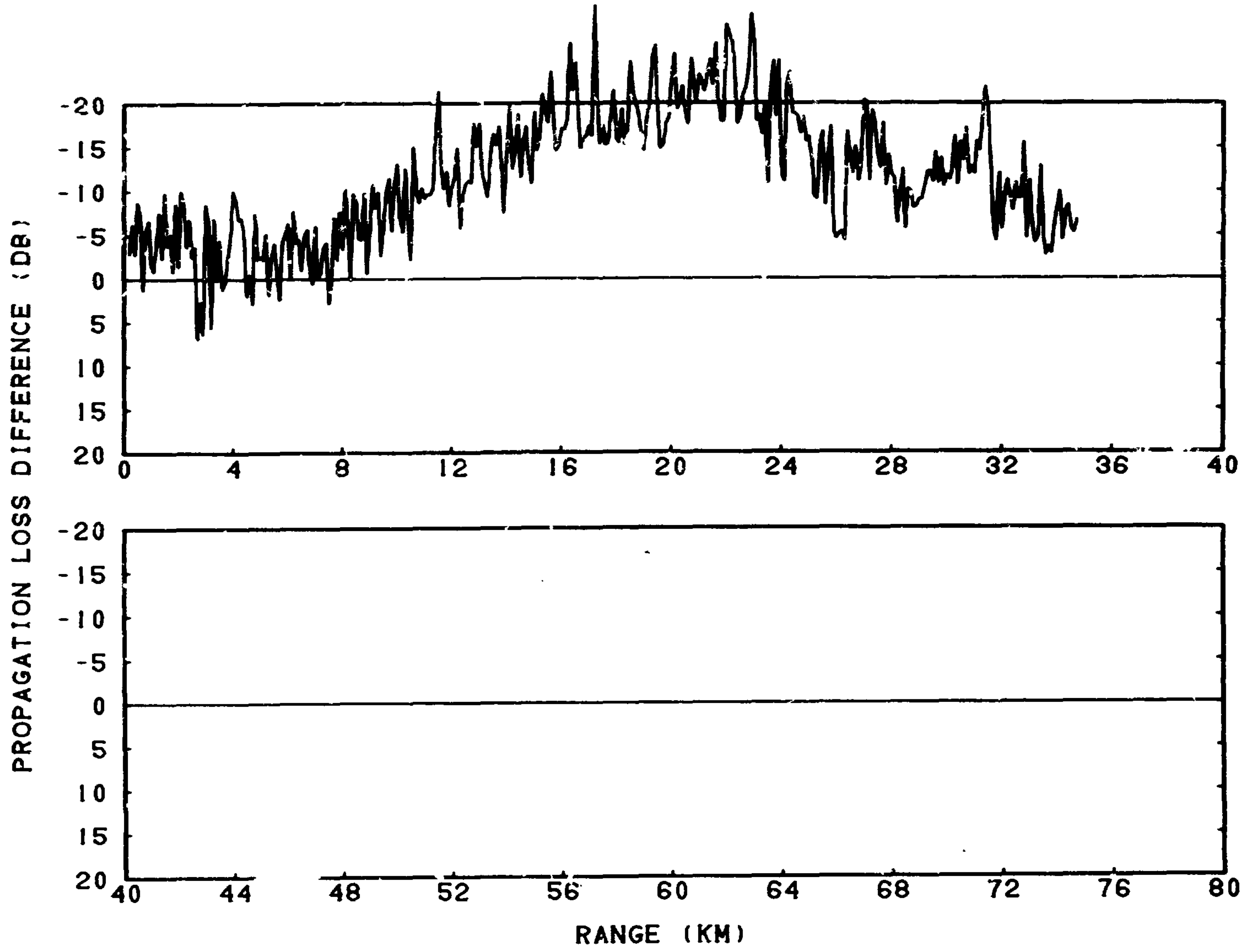
CONFIDENTIAL

(C) Figure IIIA-63. CASE X. Smoothed RAYMODE Coherent, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters, Subtracted from SUDS Data, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters



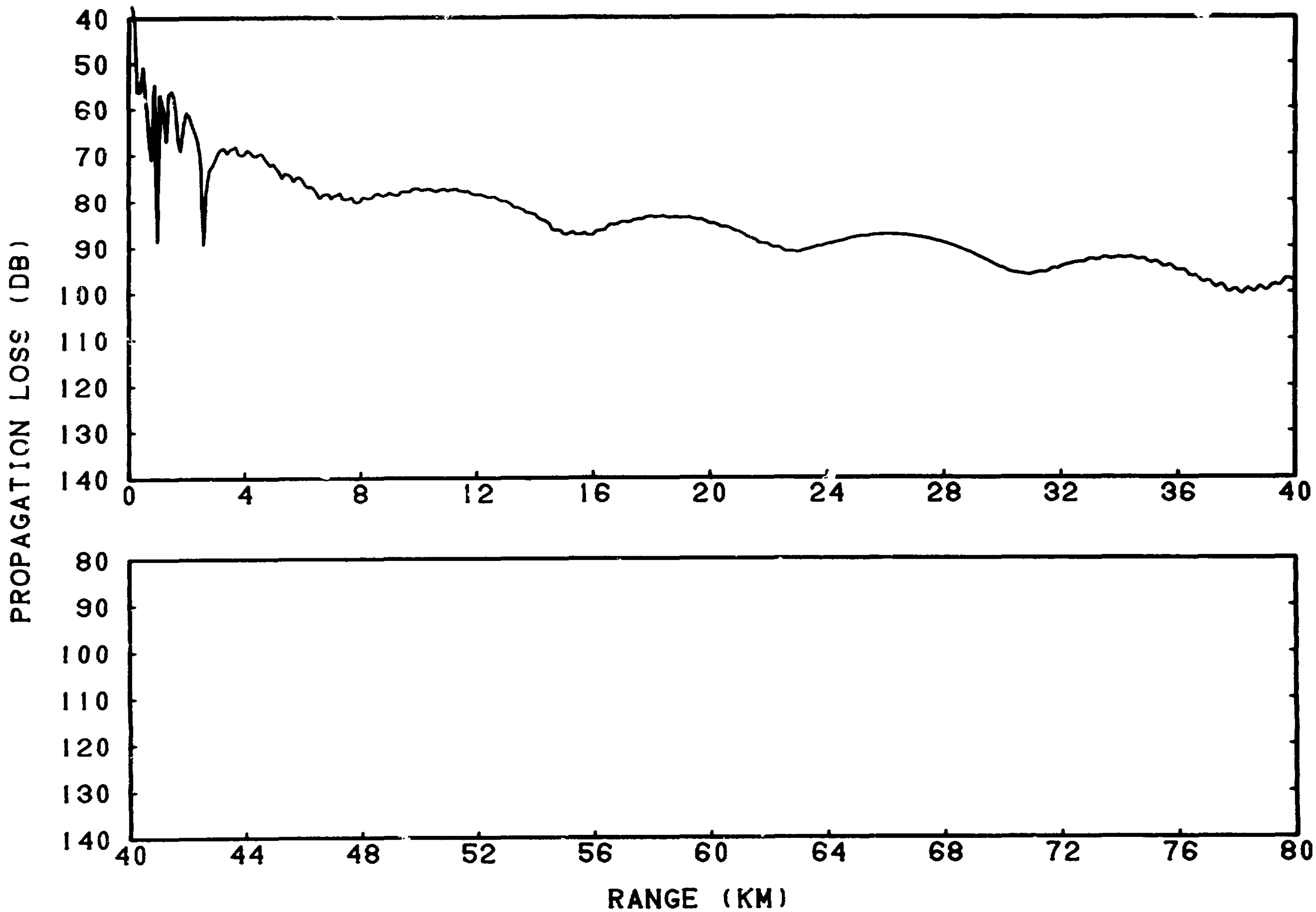
CONFIDENTIAL

(C) Figure IIIA-64. CASE X. RAYMODE Incoherent, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters



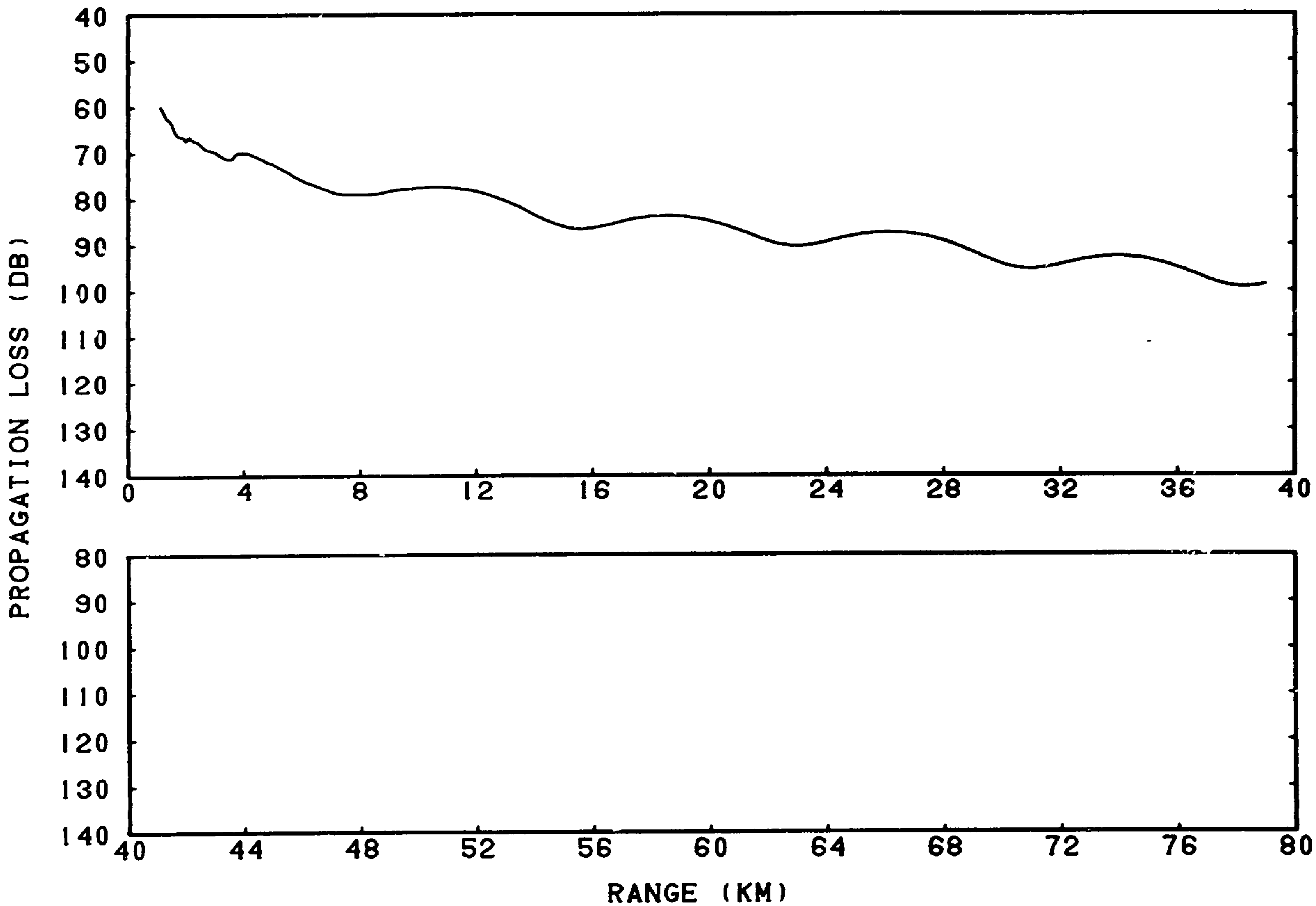
CONFIDENTIAL

(C) Figure IIIA-65. CASE X. RAYMODE Incoherent, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters, Subtracted from SUDS Data, Frequency = 3.5 Kilohertz, Source Depth = 45 Meters, Receiver Depth = 112 Meters



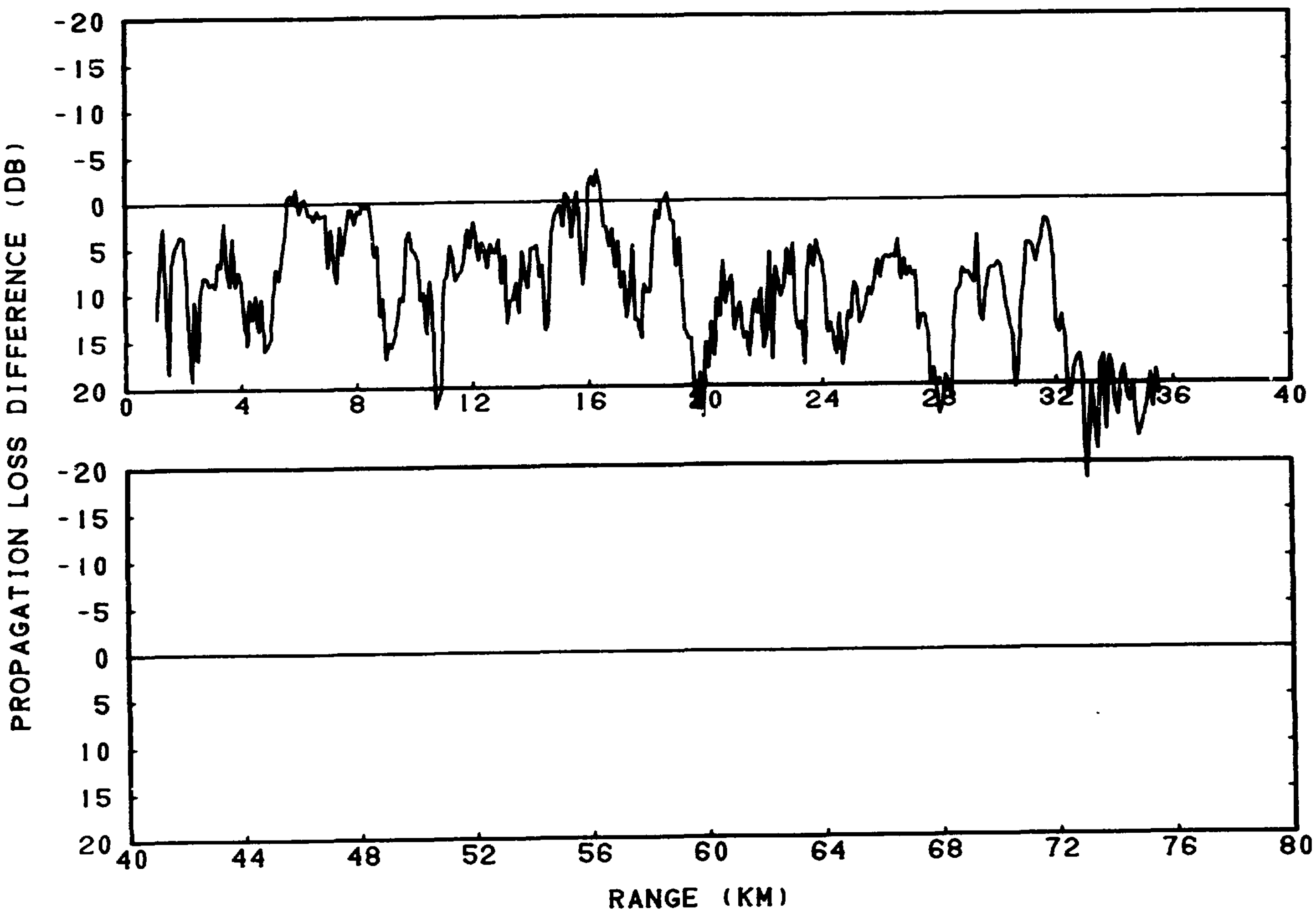
CONFIDENTIAL

(C) Figure IIIA-66. CASE XI. RAYMODE Coherent, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 17 Meters



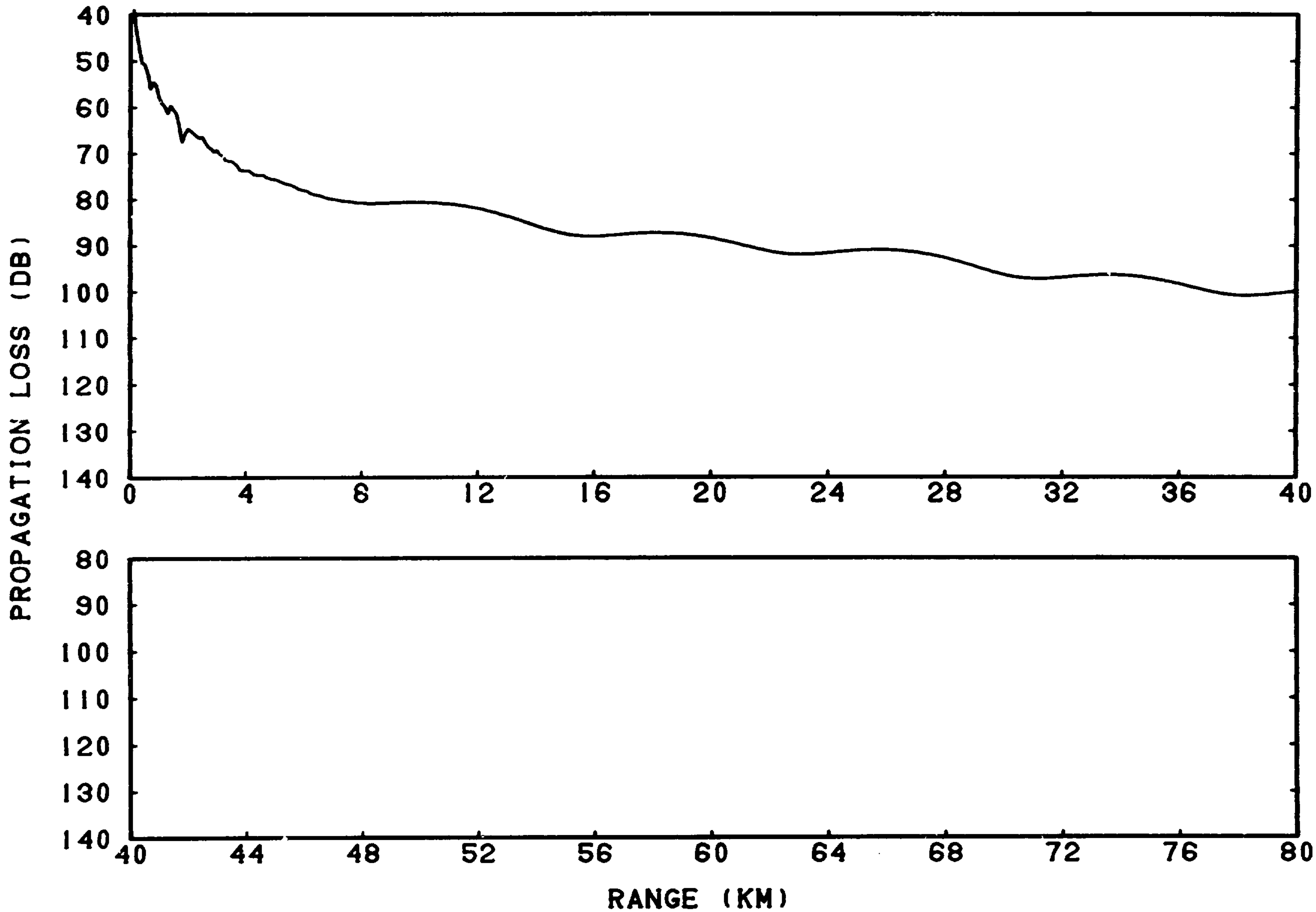
CONFIDENTIAL

(C) Figure IIIA-67. CASE XI. RAYMODE Coherent, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 17 Meters, Sliding Averages of 21 Points (1.99 Kilometer)



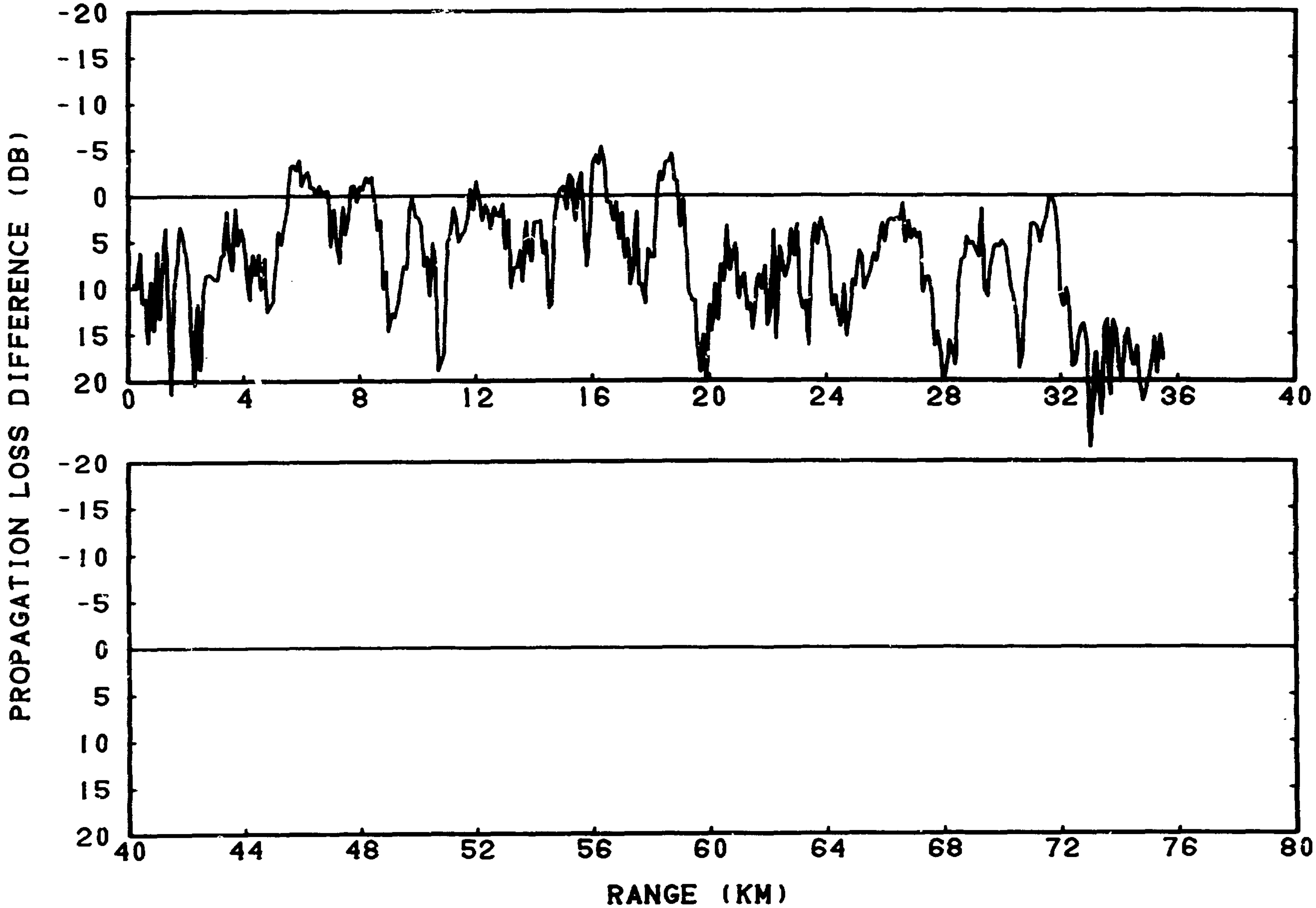
CONFIDENTIAL

(C) Figure IIIA-68. CASE XI. Smoothed RAYMODE Coherent, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 17 Meters, Subtracted from SUDS Data, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 17 Meters



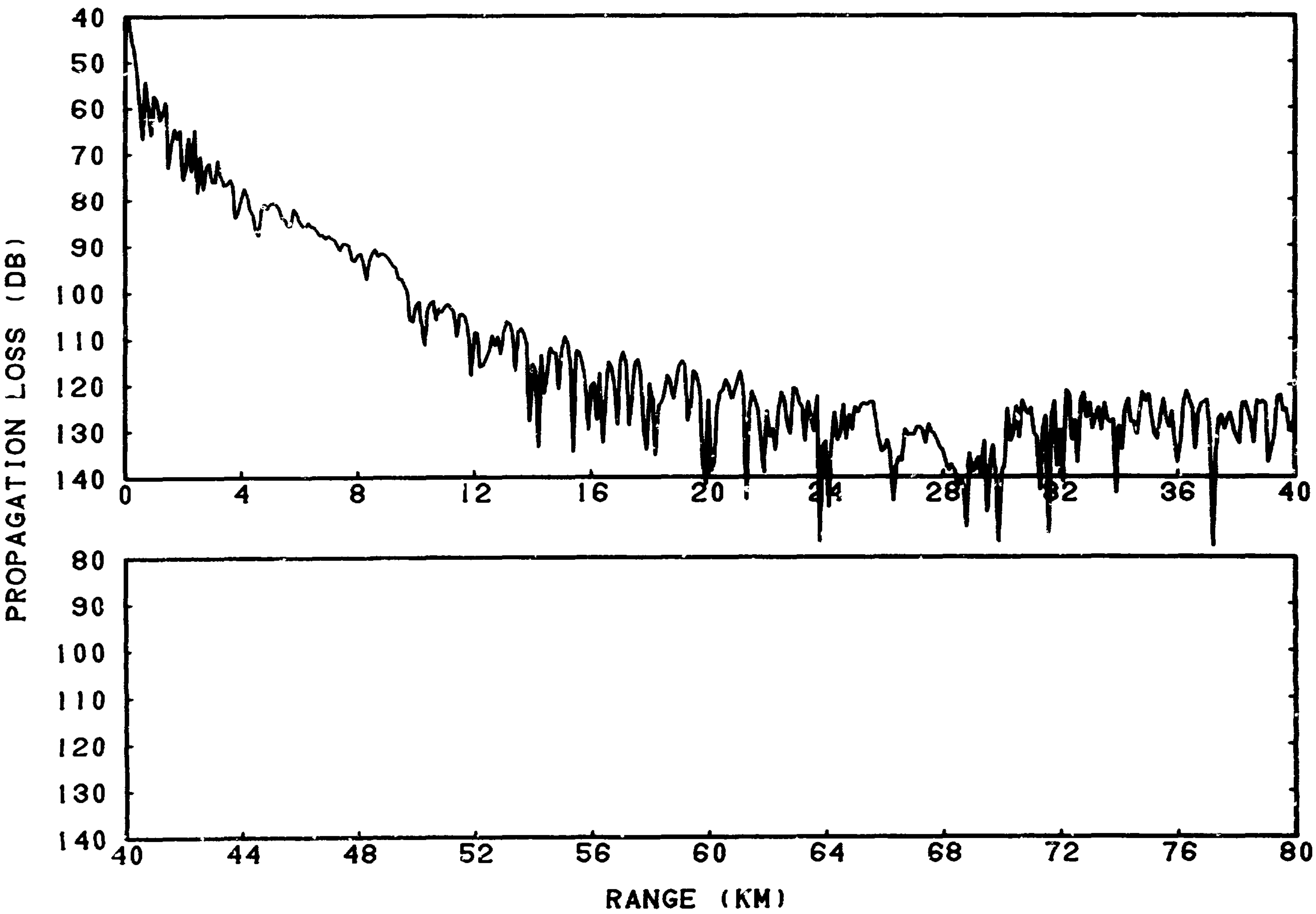
CONFIDENTIAL

(C) Figure IIIA-69. CASE XI. RAYMODE Incoherent, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 17 Meters



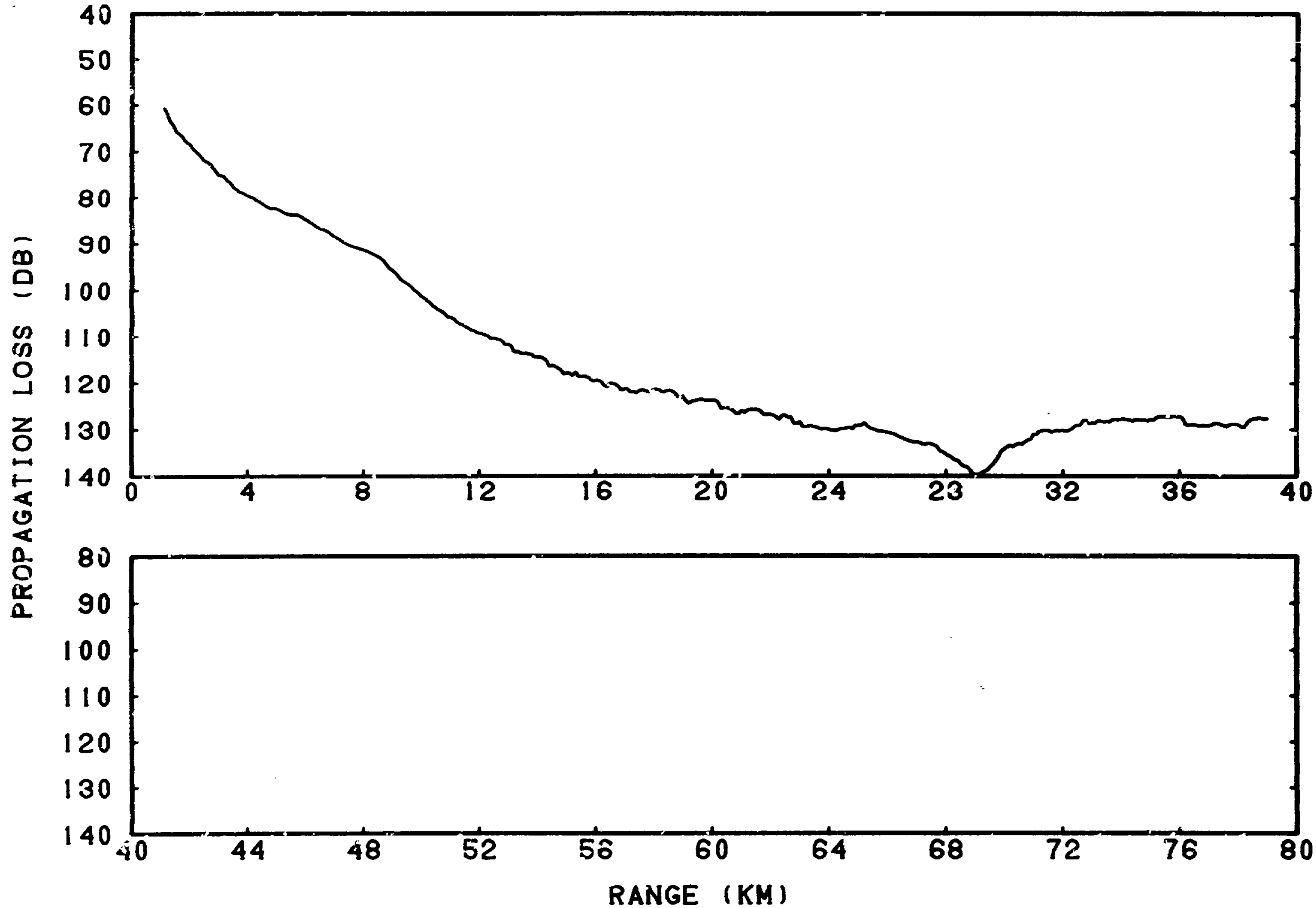
CONFIDENTIAL

(C) Figure IIIA-70. CASE XI. RAYMODE Incoherent, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 17 Meters, Subtracted from SUDS Data, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 17 Meters



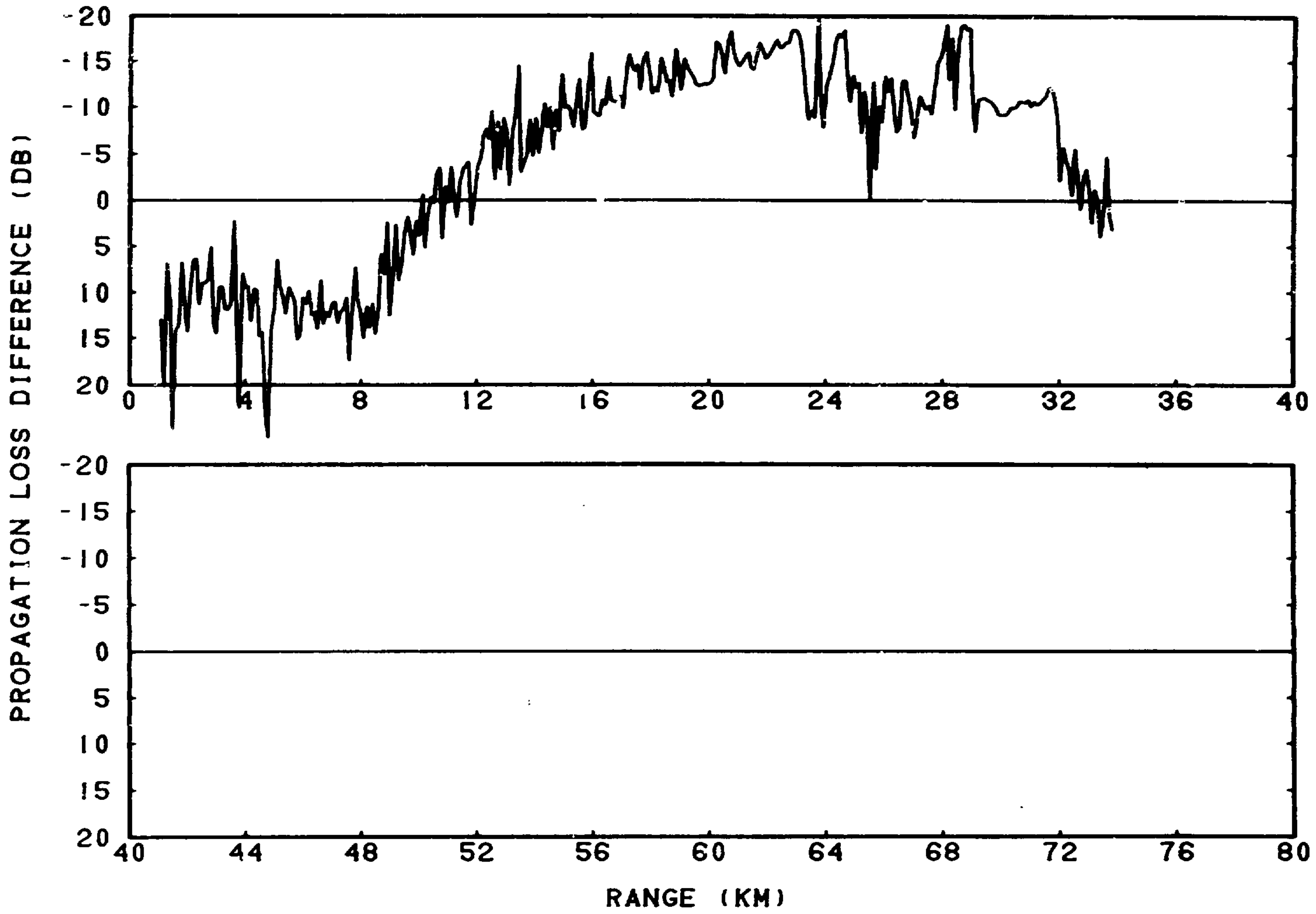
CONFIDENTIAL

(C) Figure IIIA-71. CASE XII. RAYMODE Coherent, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters



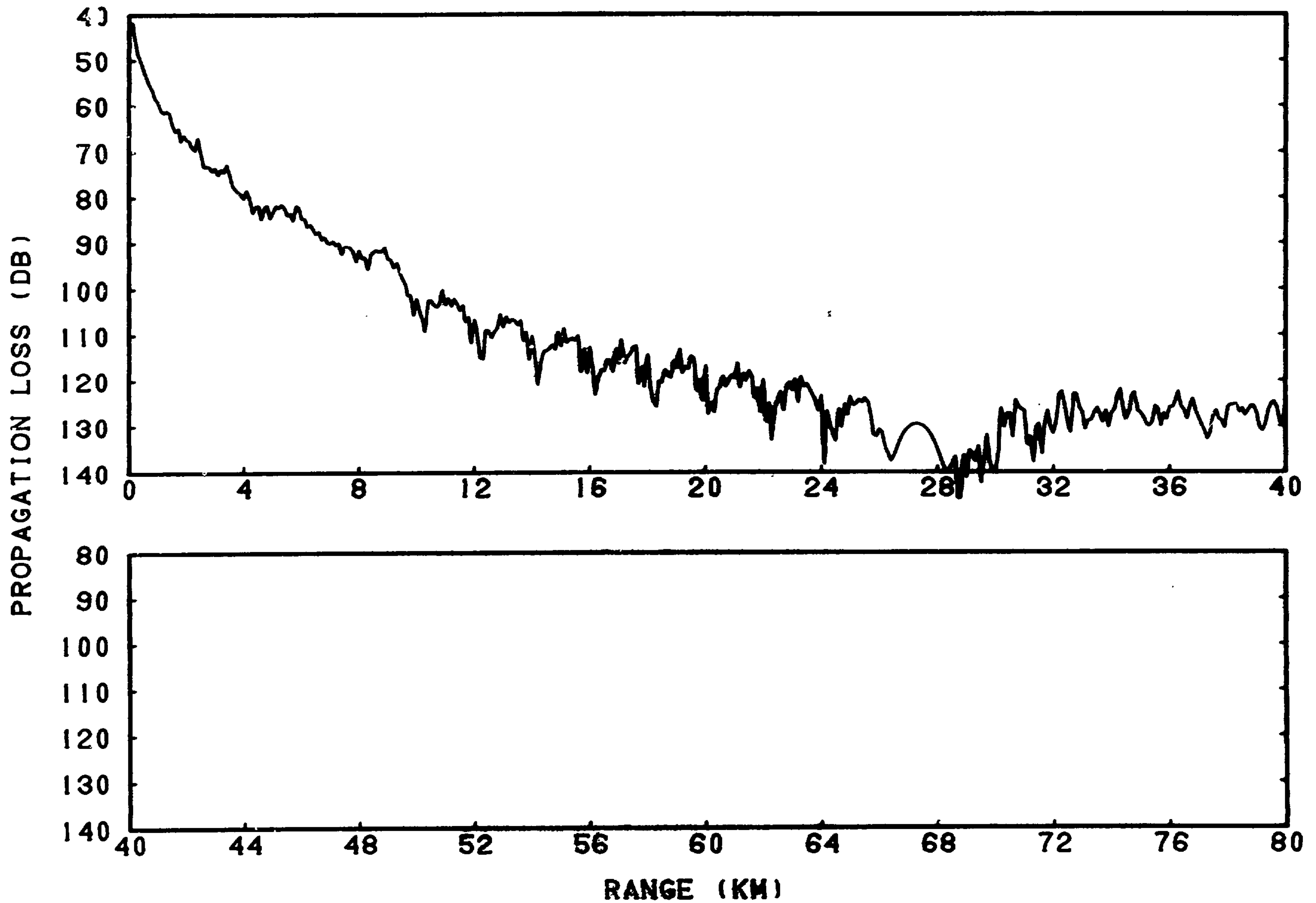
CONFIDENTIAL

(C) Figure IIIA-72. CASE XII. RAYMODE Coherent, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters, Sliding Averages of 21 Points (1.99 Kilometer)



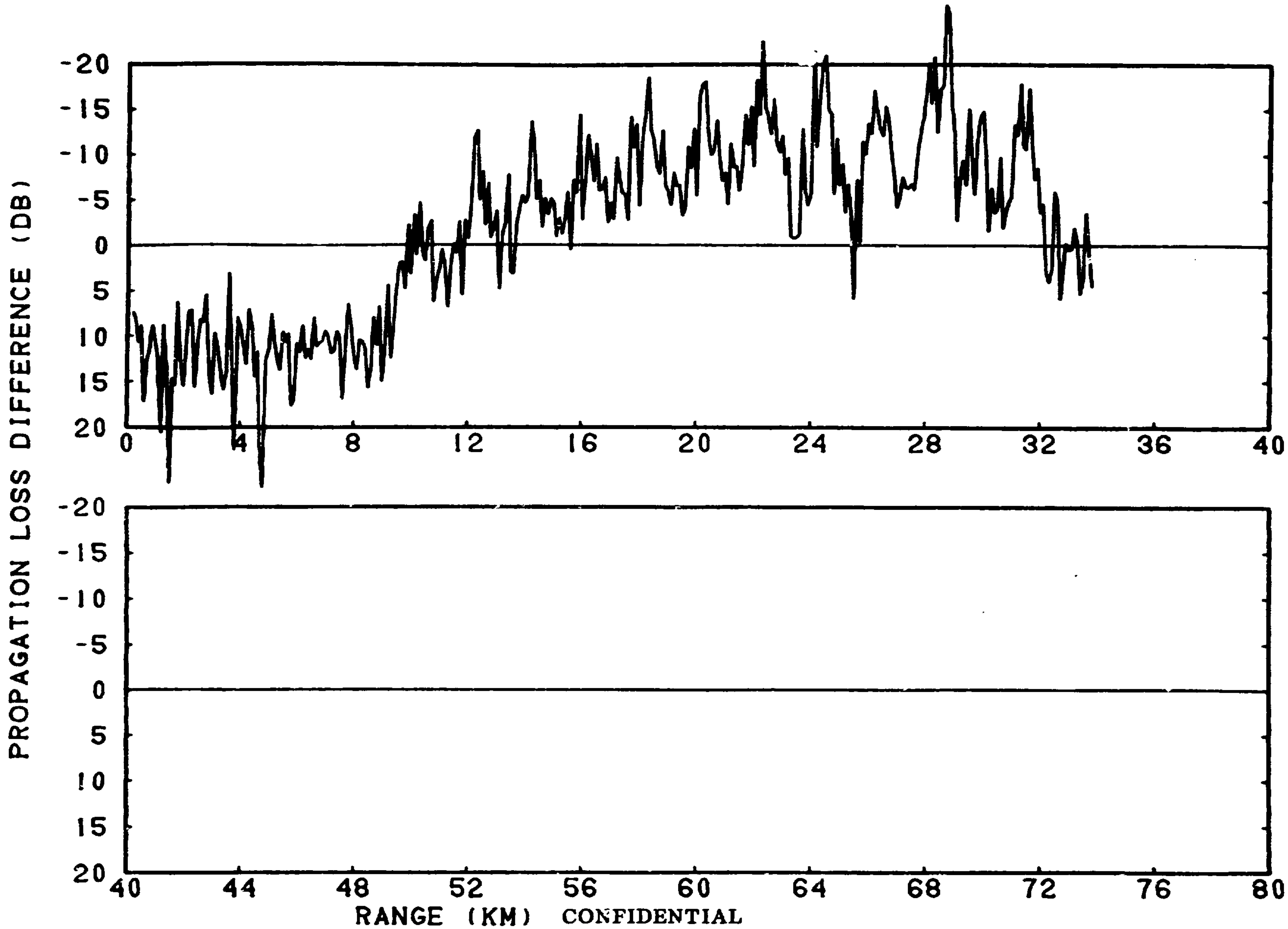
CONFIDENTIAL

(C) Figure IIIA-73. CASE XII. Smoothed RAYMODE Coherent, Frequency = 5.0 Kilohertz Source Depth = 42 Meters, Receiver Depth = 112 Meters, Subtracted from SUDS Data, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters



CONFIDENTIAL

(C) Figure IIIA-74. CASE XII. RAYMODE Incoherent, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters



CONFIDENTIAL

(C) Figure IIIA-75. CASE XII. RAYMODE Incoherent, Frequency = 5.0 Kilohertz, Source Depth = 42 Meters, Receiver Depth = 112 Meters, Subtracted from SUDS data, Frequency = 5.0 Kilohertz, Source Depth = 42 meters, Receiver Depth = 112 Meters

Appendix IIIB. Accuracy Assessment of RAYMODE X Compared to HAYS-MURPHY Mediterranean Experimental Data (U)

HAYS-MURPHY (U)

Environment (U)

(C) The Hays-Murphy data used here were collected in the Algiers-Provencal Basin of the Mediterranean Sea over a distance of 200 kilometers (km) of what is termed the St. Margarets run (Martin,1982). The St. Margarets run was much longer, but the flat bottom assumption of range independent propagation loss models was violated past 200 km. The sound speed profile is plotted and tabulated in Figure IIIB-1. The profile is essentially bilinear with a minimum at 61 meters (m). The critical depth is 1894 m, indicating a depth excess of approximately 850 m.

(C) Two sets of bottom loss tables were used as input to the RAYMODE X model. The first are the MGS bottom loss versus grazing angle curves found in subroutine MGSBL in the RAYMODE X model, and in the six cases examined below, an MGS Type 2 bottom was found to pertain at the site of the receiver. Also used as input to RAYMODE X were the FACT PL9D model's internal FNOC/NOO bottom loss tables for an FNOC Type 3 bottom. These latter tables were inputted to RAYMODE X from an external table of 91 values (corresponding to 0-90° grazing angle). The six cases of Hays-Murphy acoustic data cover four frequencies: 35.0, 67.5, 100.0 and 200.0 Hz. For the lowest three frequencies, a single bottom loss curve is found from each of the MGS and FNOC sets of curves. The MGS Type 2 curve for 100 Hz and less is given in Table IIIB-3. The MGS Type 2 curve has a critical angle of 9°, 1.6 dB bottom loss at 15°, and 8 dB loss at normal incidence. The FNOC Type 3 curve has a critical angle of 12°, 1 dB bottom loss at 15°, and 10 dB loss at normal incidence. The bottom loss curves for 200 Hz are given in Tables IIIB-2 and IIIB-4 for MGS and FNOC bottom types, respectively. The MGS Type 2 curve has 1.1 dB bottom loss at 0°, 2.7 dB at 15°, and 8.3 dB at normal incidence. The FNOC type curve has a constant bottom loss of 3 dB to 14°, 3.3 dB at 15°, and 11 dB at normal incidence.

Test Cases (U)

(C) Six test cases were chosen for experimental data/model comparison.

Case	Source Depth	Receiver Depth	Frequency (Hz)
I	24.4 m (80 ft)	137.2 m (450 ft)	35.0
II	24.4 m (80 ft)	137.2 m (450 ft)	67.5
III	24.4 m (80 ft)	137.2 m (450 ft)	100.0
IV	24.4 m (80 ft)	137.2 m (450 ft)	200.0
V	24.4 m (80 ft)	106.7 m (350 ft)	35.5
VI	24.4 m (80 ft)	106.7 m (350 ft)	100.0

CONFIDENTIAL

(C) Experimental data for the six cases is given in Figures IIIB-2 to IIIB-7. The experimental data for these cases show a frequency dependence whereby in going from 67.5 to 100.0 to 200.0 Hz the propagation loss increases by about 6 dB. There does not seem to be a significant frequency dependence in going from 35.0 to 67.5 Hz. When Case V is compared with Case I and Case VI is compared with Case III, no significant receiver depth dependence is found over the 100 ft (30.5 m) separation. In all cases, the data is free of convergence zone structure. Fluctuations of 4-5 dB in the first 100 km of data modulate an overall

decrease of approximately 10 dB and in the second 100 km, an overall decrease of 2-5 dB is modulated by 2-5 dB fluctuations. The Hays-Murphy data results from one-third octave analysis of underwater explosive detonations. The frequencies given are the geometric mean frequencies of the one-third octave bands.

Accuracy Assessment Results (U)

(C) Use of MGS (i.e., RAYMODE X) bottom loss or FNOC (i.e., FACT PL9D) bottom loss in the RAYMODE X model runs usually resulted in differences of 0.5 dB or less between mean (μ) differences between RAYMODE X output and Hays-Murphy data (as can be seen by comparing Table IIIB-5a with IIIB-6a, and IIIB-5b with IIIB-6b), with one notable exception: In Case IV, the only case at 200 Hz, a difference of 1.5 dB in means is found in the 0 to 25 km range interval, the only interval strongly affected by choice of bottom loss. We shall return to this point in greater detail below. Aside from Case IV, only the RAYMODE X results using the MGS (i.e., RAYMODE's own) bottom loss are discussed due to the slight effect of bottom loss.

(U) Accuracy assessment procedures applied to the RAYMODE X outputs and the experimental data are described in Section 1.1 of this volume and in greater detail in Section 5 of Volume I of this series (NORDA Report 33). For the six Hays-Murphy cases, no significant propagation loss features are evident in the experimental data and for calculation of statistics of differences from model results, arbitrary intervals of 0-25 km, 25-50 km, and 50-200 km were selected. The means and standard deviations of differences between Hays-Murphy experimental data and the RAYMODE X model outputs are found in Tables IIIB-5a and III-5b for the coherent and incoherent model results, respectively, where the MGS bottom loss was used. Similar results in which RAYMODE X used the FNOC bottom loss (found in FACT PL9D model) are given in Tables IIIB-6a and IIIB-6b.

The following figures were produced for each case: (1) RAYMODE X using the coherent phases addition option; (2) this coherent result smoothed by a running average of five points (i.e., a 2 km window); (3) the smoothed coherent result subtracted from the Hays-Murphy experimental data; (4) RAYMODE X output using the incoherent phase addition option; and (5) the incoherent result subtracted from the Hays-Murphy experimental data. These five curves are given first for all cases where RAYMODE X was run with its own MGS bottom loss and then for RAYMODE X run using the FNOC bottom loss for FACT PL9D. The plots are given as follows:

Case	RAYMODE (i.e., MGS) Bottom	FACT (i.e., FNOC) Bottom
I	Fig. IIIB-8 to Fig. IIIB-12	Fig. IIIB-38 to Fig. IIIB-42
II	Fig. IIIB-13 to Fig. IIIB-17	Fig. IIIB-43 to Fig. IIIB-47
III	Fig. IIIB-18 to Fig. IIIB-22	Fig. IIIB-48 to Fig. IIIB-52
IV	Fig. IIIB-23 to Fig. IIIB-27	Fig. IIIB-53 to Fig. IIIB-57
V	Fig. IIIB-28 to Fig. IIIB-32	Fig. IIIB-58 to Fig. IIIB-62
VI	Fig. IIIB-33 to Fig. IIIB-37	Fig. IIIB-63 to Fig. IIIB-67

UNCLASSIFIED

(C) In examining the means and standard deviations of the differences between Hays-Murphy data and RAYMODE X outputs, the following conclusions may be drawn: (1) In all cases the model exhibits greater loss than does the experimental data (indicating that the model prediction is overly pessimistic). The mean differences vary from 3 to 11 dB. Bottom parameter measurements near the site (DiNapoli, 1972), when converted to bottom loss via a Rayleigh model that

includes attenuation in the bottom, result in a bottom loss versus grazing angle curve with a critical angle of 20° and a normal incidence loss of 5.9 dB. This is lower than either the MGS or FNOC bottom loss results given in Tables IIIB-1 through IIIB-4, and its use would likely eliminate the mean differences within the first region (i.e., to 25 km). (2) The standard deviations of differences between Hays-Murphy data and RAYMODE results are generally smaller for the incoherent predictions than for the coherent predictions generally by about 2 dB. This is not surprising, since the model's incoherent addition has a smoothing effect as does averaging over a one-third octave frequency band for the experimental data. (3) For the incoherent RAYMODE results, standard deviation of differences between Hays-Murphy data and RAYMODE outputs are between 2.5 and 5.5 dB. (4) There is no significant difference between use of the MGS bottom loss (found in RAYMODE) and the FNOC bottom loss (found in the FACT PL9D model). (5) Particularly for the incoherent results, the agreement between model results and Hays-Murphy data is best at 200 Hz and significantly better than results for the other three frequencies. We recall that the lower three frequencies all used the same bottom loss table and therefore conclude that the difference in bottom loss probably accounted for the improved loss at 200 Hz (Note: This applies to only the first bottom bounce region (i.e., to 25 km) beyond which bottom bounce paths are not significant contributors.)

(C) The figure of merit (FOM) versus detection range analysis for the six Hays-Murphy cases are given in Tables IIIB-7 when RAYMODE X uses its own (i.e., MGS) bottom loss and in Tables IIIB-8 when RAYMODE X uses the bottom loss of the FACT PL9D model (i.e., FNOC). For an FOM of 75 dB, RAYMODE incoherent results show detection coverage from 0 to 2.0-4.5 km for the six cases. The RAYMODE coherent results show coverage from 0 to 1.5-3.5 km and zonal detection coverage (ZDC, Zonal Detection Coverage, is given in percentage of the indicated range interval for which detection is possible) of 30% extending to ranges as great as 14 km. In contrast, the Hays-Murphy experimental data generally shows continuous coverage to about 20 km and ZDC of generally 60% to range of about 40 km. At FOM=80 dB, RAYMODE incoherent coverage is continuous to about 12 km; for RAYMODE coherent results, continuous coverage extends to about 4 km and ZDC of variable percentages extend coverage to ranges as great as 45 km (often with large gaps). The Hays-Murphy data has continuous detection coverage to 42-55 km over the six cases. ZDC of generally 50% extends to ranges from 84 to 113 km. At FOM=85 dB, RAYMODE incoherent detection coverage is continuous to 47 km. For RAYMODE coherent, continuous coverage is generally to 6 km followed by ZDCs of about 50% to about 50 km and ZDCs of 5-15% to ranges of about 100 km. The Hays-Murphy data shows continuous coverage for most cases to 130 km and ZDC at percentages above 50% to ranges of 170 km or more. Finally, at FOM=90 dB, the RAYMODE incoherent predictions show continuous coverage to 95 km and, typically, spotty coverage to about 140 km. RAYMODE coherent gives continuous coverage to 6 km and ZDCs of varying percentages to ranges from 120 to over 195 km over the six cases. For all cases, Hays-Murphy experimental data shows continuous coverage to greater than 200 km.

(C) General conclusions based on comparison of RAYMODE X outputs with Hays-Murphy experimental data follow: (1) Significant differences in mean levels were primarily responsible for pessimistic detection range predictions by the model. These differences appear to be attributable to the bottom loss inputs for the first bottom bounce region (i.e., to 25 km). Beyond this range, differences are as great and unexplained, but bottom loss is not a factor. It is to be noted that for this scenario, RAYMODE and FACT bottom loss inputs led to essentially the same results. (2) Mean differences between the

Hays-Murphy data and the RAYMODE model were smaller by about 2 dB for incoherent results as compared to coherent results. This is reversed for standard deviations of differences between the model and Hays-Murphy data for which RAYMODE coherent generally showed about 2 dB greater standard deviation than did RAYMODE incoherent. The net effect is that the RAYMODE incoherent curve is in better agreement with the experimental data than is the RAYMODE coherent curve with regard to general characteristics (i.e., shape) but the RAYMODE coherent results are more in agreement with the experimental data with regard to detection range coverage (although the agreement is far from satisfactory). This is understandable since detections, particularly of a zonal nature, are determined more by fluctuations than by mean levels (particularly for average signal-to-noise ratios that are negative or near zero.

References (U)

DiNapoli, F. R., et al. (1972). Acoustic Model for an FBM Sonar Trainer: Part I-Low-Frequency Acoustic Propagation (U). NUSC Tech. Memo. No. PA4-02-72 (CONFIDENTIAL).

Martin, R. L., et al. (1982). Summary of Range-Independent Environmental Acoustic Propagation Data Sets (U). Vol. IA, The Acoustic Model Evaluation Committee (AMEC) Reports, NORDA Report 34, Naval Ocean Research and Development Activity, NSTL Station, Miss. (CONFIDENTIAL)

(U) Table IIIB-1. Bottom Loss in dB Versus Grazing Angle in Degrees. MGS Bottom Type 2. Frequency $\leq$ 100 Hertz.

Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL
0	0.00	15	1.92	30	5.23	45	7.25	60	8.28	75	8.54
1	0.00	16	2.19	31	5.40	46	7.34	61	8.32	76	8.54
2	0.00	17	2.45	32	5.57	47	7.44	62	8.36	77	8.52
3	0.00	18	2.70	33	5.73	48	7.53	63	8.39	78	8.51
4	0.00	19	2.95	34	5.88	49	7.61	64	8.42	79	8.49
5	0.00	20	3.19	35	6.03	50	7.69	65	8.45	80	8.48
6	0.00	21	3.42	36	6.17	51	7.77	66	8.47	81	8.45
7	0.00	22	3.65	37	6.31	52	7.84	67	8.49	82	8.43
8	0.00	23	3.87	38	6.45	53	7.91	68	8.51	83	8.40
9	0.14	24	4.08	39	6.57	54	7.97	69	8.52	84	8.37
10	0.46	25	4.29	40	6.70	55	8.03	70	8.53	85	8.33
11	0.77	26	4.49	41	6.82	56	8.09	71	8.54	86	8.30
12	1.07	27	4.68	42	6.93	57	8.14	72	8.55	87	8.26
13	1.36	28	4.87	43	7.04	58	8.19	73	8.55	88	8.21
14	1.64	29	5.05	44	7.15	59	8.24	74	8.55	89	8.17

UNCLASSIFIED

(U) Table IIIB-2. Bottom Loss in dB Versus Grazing Angle in Degrees.
MGS Bottom Type 2. Frequency = 200 Hertz.

O	BL	O	BL	O	BL	O	BL	O	BL	O	BL
0	1.08	15	2.88	30	5.51	45	7.16	60	8.08	75	8.43
1	1.12	16	3.09	31	5.65	46	7.24	61	8.12	76	8.43
2	1.15	17	3.30	32	5.78	47	7.32	62	8.16	77	8.43
3	1.19	18	3.50	33	5.91	48	7.40	63	8.19	78	8.43
4	1.22	19	3.69	34	6.03	49	7.47	64	8.22	79	8.43
5	1.26	20	3.88	35	6.15	50	7.54	65	8.25	80	8.43
6	1.29	21	4.07	36	6.27	51	7.61	66	8.28	81	8.42
7	1.32	22	4.25	37	6.38	52	7.67	67	8.31	82	8.41
8	1.35	23	4.42	38	6.49	53	7.73	68	8.33	83	8.40
9	1.48	24	4.59	39	6.60	54	7.79	69	8.35	84	8.39
10	1.73	25	4.76	40	6.70	55	7.84	70	8.37	85	8.38
11	1.97	26	4.92	41	6.80	56	7.90	71	8.38	86	8.36
12	2.21	27	5.07	42	6.90	57	7.95	72	8.40	87	8.34
13	2.44	28	5.22	43	6.99	58	7.99	73	8.41	88	8.32
14	2.66	29	5.37	44	7.08	59	8.04	74	8.42	89	8.30

UNCLASSIFIED

(U) Table IIIB-3. Bottom Loss in dB Versus Grazing Angle in Degrees. FNOC Bottom Type 3. Frequency $\leq$ 150 Hertz.

θ	BL
0	0.0
11	0.0
20	3.0
25	4.4
35	6.7
45	8.5
56	10.0
90	10.0

UNCLASSIFIED

(U) Table IIIB-4. Bottom Loss in dB Versus Grazing Angle in Degrees. FNOC Bottom Type 3. Frequency = 200 Hertz.

θ	BL
0	3.0
13	3.0
20	5.3
35	8.7
45	10.3
53	11.0
90	11.0

UNCLASSIFIED

(U) Table IIIB-5a. Means (μ) and Standard Deviations (σ) in dB of Differences Between Hays-Murphy Experimental Data and RAYMODE X Coherent Model Output.[1] Bottom Loss = MGS Type 2.

Case	Frequency (Hz)	Source Depth (ft)	Receiver Depth (ft)	0-25 km		25-50 km		50-200 km	
				μ	σ	μ	σ	μ	σ
I	35.0	80	450	-9.3	3.8	-9.2	3.1	-9.3	3.3
II	67.5	80	450	-10.3	5.1	-10.9	4.0	-10.9	2.7
III	100.0	80	450	-9.6	4.9	-7.8	5.3	-8.9	3.6
IV	200.0	80	450	-6.0	3.4	-6.1	5.5	-8.4	4.2
V	35.0	80	350	-7.6	4.7	-10.9	2.5	-10.5	3.1
VI	100.0	80	350	-9.1	5.3	-6.7	6.2	-7.4	4.1

1. Smoothed by application of a 2 kilometer window moving average.

CONFIDENTIAL

(U) Table IIIB-5b. Means (μ) and Standard Deviations (σ) in dB of Differences Between Hays-Murphy Experimental Data and RAYMODE X Incoherent Model Output. Bottom Loss = MGS Type 2.

Case	Frequency (Hz)	Source Depth (ft)	Receiver Depth (ft)	0-25 km		25-50 km		50-200 km	
				μ	σ	μ	σ	μ	σ
I	35.0	80	450	-8.6	3.6	-8.1	2.9	-7.8	2.2
II	67.5	80	450	-8.6	2.2	-8.4	2.3	-8.6	1.5
III	100.0	80	450	-6.7	2.2	-6.0	3.0	-6.4	2.0
IV	200.0	80	450	-3.2	2.1	-2.5	3.6	-3.9	1.8
V	35.0	80	350	-7.3	3.2	-7.5	2.1	-7.4	1.9
VI	100.0	80	350	-5.6	2.1	-4.7	2.9	-5.1	1.6

CONFIDENTIAL

(U) Table IIIB-6a. Means (μ) and Standard Deviations (σ) in dB of Differences Between Hays-Murphy Experimental Data and RAYMODE X Coherent Model Output.[1] Bottom Loss = FNOC Type 3.

Case	Frequency (Hz)	Source Depth (ft)	Receiver Depth (ft)	0-25 km		25-50 km		50-200 km	
				μ	σ	μ	σ	μ	σ
I	35.0	80	450	-9.2	3.8	-8.7	2.9	-9.1	3.3
II	67.5	80	450	-10.8	5.9	-10.5	4.1	-10.4	3.0
III	100.0	80	450	-10.2	5.3	-7.7	5.4	-8.5	3.7
IV	200.0	80	450	-7.5	3.7	-6.5	5.5	-8.8	4.4
V	35.0	80	350	-7.6	4.8	-10.5	2.4	-9.9	2.9
VI	100.0	80	350	-9.7	5.7	-6.6	6.3	-7.1	4.3

1. Smoothed by application of a 2 kilometer window moving average.

CONFIDENTIAL

(U) Table IIIB-6b. Means (μ) and Standard Deviations (σ) in dB of Differences Between Hays-Murphy Experimental Data and RAYMODE X Incoherent Model Output. Bottom Loss = FNOC Type 3.

Case	Frequency (Hz)	Source Depth (ft)	Receiver Depth (ft)	0-25 km		25-50 km		50-200 km	
				μ	σ	μ	σ	μ	σ
I	35.0	80	450	-8.6	3.4	-7.8	2.9	-7.5	2.2
II	67.5	80	450	-8.7	2.1	-8.1	2.3	-8.3	1.5
III	100.0	80	450	-6.8	2.2	-5.7	3.1	-6.1	2.0
IV	200.0	80	450	-4.9	1.9	-3.3	3.9	-4.5	2.1
V	35.0	80	350	-7.3	2.9	-7.2	2.0	-7.1	1.9
VI	100.0	80	350	-5.7	2.1	-4.4	2.9	-4.8	1.8

CONFIDENTIAL

(C) Table IIIB-7a. Detection Range in Kilometer as a Function of
Figure of Merit (FOM) in dB for Hays-Murphy
Mediterranean Experimental Data and
RAYMODE X Model Predictions
Case I:
(Source Depth = 80 ft., Receiver Depth = 450 ft., Frequency = 35 Hz)
Bottom Loss: MGS Type 2

Data Set	FOM	R_c [1]	Range > R_c
Hays-Murphy	75	25.5	ZDC[2] 60%, 25.5-44 km
RAYMODE X Coherent	75	3.5	ZDC 35%, 5.5-14 km
RAYMODE X Incoherent	75	4.5	
Hays-Murphy	80	54.5	ZDC 50%, 54.5-93 km
RAYMODE X Coherent	80	4.5	ZDC 50%, 5-16 km; ZDC 20%, 24-39 km
RAYMODE X Incoherent	80	12.0	
Hays-Murphy	85	130.5	ZDC 50%, 130.5-172.5 km
RAYMODE X Coherent	85	5.0	ZDC 70%, 5-47 km, ZDC 15%, 57-66.5 km ZDC 15%, 104-112 km
RAYMODE X Incoherent	85	47.5	
Hays-Murphy	90	>200	
RAYMODE X Coherent	90	6.5	100% coverage 7.5-16.5 km, 17-41 km; ZDC 70%, 41-155 km
RAYMODE X Incoherent	90	93.5	100% coverage 103-112.5 km, 123.5-125.5 km, 141-142 km

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval for which detection is possible.

CONFIDENTIAL

(C) Table IIIB-7b. Detection Range in Kilometer as a Function of Figure of Merit (FOM) in dB for Hays-Murphy Mediterranean Experimental Data and RAYMODE X Model Predictions
Case II:
(Source Depth = 80 ft., Receiver Depth = 450 ft., Frequency = 67.5 Hz)
Bottom Loss: MGS Type 2

Data Set	FOM	R_c[1]	Range > R_c
Hays-Murphy	75	42.5	
RAYMODE X Coherent	75	1.5	ZDC[2] 50%, 1.5-7 km
RAYMODE X Incoherent	75	3.0	
Hays-Murphy	80	54.0	ZDC 50%, 54-113 km
RAYMODE X Coherent	80	3.5	ZDC 60%, 4-7.5 km, 100% coverage 13.5-15.5 km, and 19-22.5 km; ZDC 20%, 30-45 km
RAYMODE X Incoherent	80	11.0	100% coverage 136-137 km
Hays-Murphy	85	>200	Except for a few dropouts of ≤ km
RAYMODE X Coherent	85	6.5	ZDC 45%, 7.5-47.5; ZDC 20%, 59-79.5 km, ZDC <5%, 91.5-115; peak at 143.5 km
RAYMODE X Incoherent	85	47	
Hays-Murphy	90	>200	
RAYMODE X Coherent	90	7.5	ZDC 65%, 8-50.5 km; ZDC 55%, 55-124 km; ZDC 20% 134.5-159 km; ZDC 15%, 186-194 km
RAYMODE X Incoherent	90	95	100% coverage 101.5-107 km, 113.5-116 km and 136.5-140 km

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval for which detection is possible.

CONFIDENTIAL

(C) Table IIIB-7c. Detection Range in Kilometer as a Function of Figure of Merit (FOM) in dB for Hays-Murphy Mediterranean Experimental Data and RAYMODE X Model Predictions
Case III:
(Source Depth = 80 ft., Receiver Depth = 450 ft., Frequency = 100 Hz)
Bottom Loss: MGS Type 2

Data Set	FOM	R_c[1]	Range > R_c
Hays-Murphy	75	17.5	ZDC[2] 60%, 17.5-42 km
RAYMODE X Coherent	75	2.5	Peaks at 4, 5, 9, and 10.5 km
RAYMODE X Incoherent	75	2.5	
Hays-Murphy	80	43.5	ZDC 20%, 43.5-84 km
RAYMODE X Coherent	80	3.5	ZDC 30%, 3-13 km; Peak at 39 km 100% coverage 23-27.5 km and 45-46 km
RAYMODE X Incoherent	80	12.0	100% coverage 34.5-36 km
Hays-Murphy	85	127.5	ZDC 70%, 127.5-190 km
RAYMODE X Coherent	85	6.0	ZDC 80%, 7.5-13.5 km; ZDC 75%, 17.5-54 km ZDC 5%, 78.5-104 km; Peak at 133.5 km
RAYMODE X Incoherent	85	47.0	
Hays-Murphy	90	>200	
RAYMODE X Coherent	90	6.0	ZDC 70% 7.0-59.5 km; ZDC 40%, 61.5-106 km; ZDC 10% 108-127.5 km; ZDC 60% 130-145 km; ZDC 20% 183-193 km; ZDC 60% 115-119 km; ZDC 65% 128-138 km
RAYMODE X Incoherent	90	96	100% coverage 99-106 km, 108-112 km

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval for which detection is possible.

CONFIDENTIAL

(C) Table IIIB-7d. Detection Range in Kilometer as a Function of Figure of Merit (FOM) in dB for Hays-Murphy Mediterranean Experimental Data and RAYMODE X Model Predictions
Case IV:
(Source Depth = 80 ft., Receiver Depth = 450 ft., Frequency = 200 Hz)
Bottom Loss: MGS Type 2

Data Set	FOM	R_c[1]	Range > R_c
Hays-Murphy	75	21.5	ZDC[2] 90%, 21.5-37.5 km
RAYMODE X Coherent	75	2.0	Peaks at 3.5 and 12 km
RAYMODE X Incoherent	75	2.0	
Hays-Murphy	80	42.5	ZDC 50%, 42.5-95 km
RAYMODE X Coherent	80	2.0	ZDC 20%, 2.5-24 km; peak at 44 km
RAYMODE X Incoherent	80	3.0	100% coverage 3-9 km
Hays-Murphy	85	194	
RAYMODE X Coherent	85	2.0	ZDC 35%, 2.5-48 km; peaks at 66 and 133 km
RAYMODE X Incoherent	85	47.5	
Hays-Murphy	90	>200	
RAYMODE X Coherent	90	2.0	ZDC 45%, 2.0-49 km; ZDC 20%, 54.5-101.5 km ZDC 20%, 125-137 km; ZDC 35%, 163-167.5 km
RAYMODE X Incoherent	90	49.5	100% coverage 63.5-81 km, 84-87.5 km, 99-103.5 km and 132-134 km

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval for which detection is possible.

CONFIDENTIAL

(C) Table IIIB-7e. Detection Range in Kilometer as a Function of Figure of Merit (FOM) in dB for Hays-Murphy Mediterranean Experimental Data and RAYMODE X Model Predictions
Case V:
(Source Depth = 80 ft., Receiver Depth = 350 ft., Frequency = 35 Hz)
Bottom Loss: MGS Type 2

Data Set	FOM	R_c[1]	Range > R_c
Hays-Murphy	75	25.5	ZDC[2] 50%, 25.5-47 km
RAYMODE X Coherent	75	3.5	100% coverage 8.5-10 km; peak at 17.5 km
RAYMODE X Incoherent	75	4.0	
Hays-Murphy	80	55.0	ZDC 40% 55-93 km
RAYMODE X Coherent	80	5.5	ZDC 45%, 5.5-23 km; ZDC 20%, 33.5-38 km
RAYMODE X Incoherent	80	12.0	
Hays-Murphy	85	118.0	ZDC 50%, 118-188 km
RAYMODE X Coherent	85	6.5	100% coverage 8-12.5 km, 14-23.5 km; ZDC 50% 24-47 km; ZDC 5%, 50-81.5 km
RAYMODE X Incoherent	85	47.0	
Hays-Murphy	90	>200	
RAYMODE X Coherent	90	7.0	100% coverage 7.5-12.5 km, 13-25 km ZDC 65%, 25.5-88 km; ZDC 20%, 96-119 km
RAYMODE X Incoherent	90	93.0	ZDC 40%, 103-143 km

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval for which detection is possible.

CONFIDENTIAL

(C) Table IIIB-7f. Detection Range in Kilometer as a Function of Figure of Merit (FOM) in dB for Hays-Murphy Mediterranean Experimental Data and RAYMODE X Model Predictions
Case VI:
(Source Depth = 80 ft., Receiver Depth = 350 ft., Frequency = 100 Hz)
Bottom Loss: MGS Type 2

Data Set	FOM	R_c [1]	Range > R_c
Hays-Murphy	75	17.0	ZDC[2] 10%, 17-41 km
RAYMODE X Coherent	75	2.5	Peaks at 4 km, 9 km, 11 km
RAYMODE X Incoherent	75	2.5	
Hays-Murphy	80	42.0	ZDC 10%, 42-52 km
RAYMODE X Coherent	80	4.5	ZDC 35%, 4.5-13.5 km; ZDC 20%, 23-28 km 100% coverage 44-46 km and 46.5-47 km
RAYMODE X Incoherent	80	3.0	100% coverage 3.5-12 km, 35-36.5 km
Hays-Murphy	85	54.0	ZDC 90%, 52-127 km
RAYMODE X Coherent	85	5.0	ZDC 50%, 6-55 km; ZDC 25%, 68.5-95 km
RAYMODE X Incoherent	85	47.0	
Hays-Murphy	90	>200	
RAYMODE X Coherent	90	5.0	ZDC 70%, 5-59.5 km; ZDC 55%, 65-116 km; ZDC 45%, 124-147.5 km; ZDC 30%, 171-191.5 km
RAYMODE X Incoherent	90	94.0	ZDC 60%, 99-138.5 km

1. R_c = Range to which detection coverage is continuous.
2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval for which detection is possible.

CONFIDENTIAL

(C) Figure IIIB-8a. Detection Range in Kilometer as a Function of Figure of Merit (FOM) in dB for Hays-Murphy Mediterranean Experimental Data and RAYMODE X Model Predictions
Case I:
(Source Depth = 80 ft., Receiver Depth = 450 ft., Frequency = 35 Hz)
Bottom Loss: FNOC Type 3

Data Set	FOM	R_c[1]	Range > R_c
Hays-Murphy	75	25.5	ZDC[2] 60%, 25.5-44 km
RAYMODE X Coherent	75	4.0	100% coverage 7.5-8.5 km and 12-14 km and peak at 5 km
RAYMODE X Incoherent	75	4.5	
Hays-Murphy	80	54.5	ZDC 50%, 54.5-93 km
RAYMODE X Coherent	80	4.5	ZDC 60%, 5-16 km; ZDC 15%, 22-40 km
RAYMODE X Incoherent	80	15.0	
Hays-Murphy	85	130.5	ZDC 50%, 130.5-172.5 km
RAYMODE X Coherent	85	6.5	ZDC 65%, 7.5-51.5 km; ZDC 15%, 57.5-76 km
RAYMODE X Incoherent	85	48	
Hays-Murphy	90	>200	
RAYMODE X Coherent	90	6.5	ZDC 65%, 43.0-155 km 100% coverage 7.0-16 km, 16.5-42.5 km
RAYMODE X Incoherent	90	100	100% coverage 101.5-120 km, 133-135.5 km; 140-142 km

1. R_c = Range to which detection coverage is continuous.
2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval for which detection is possible.

(C) Table IIIB-8b. Detection Range in Kilometer as a Function of Figure of Merit (FOM) in dB for Hays-Murphy Mediterranean Experimental Data and RAYMODE X Model Predictions
Case II:
(Source Depth = 80 ft., Receiver Depth = 450 ft., Frequency = 67.5 Hz)
Bottom Loss: FNOC Type 3

Data Set	FOM	R_c[1]	Range > R_c
Hays-Murphy	75	42.5	
RAYMODE X Coherent	75	1.5	100% coverage 2-3.5 km, 5-6 km and a peak at 4.5 km
RAYMODE X Incoherent	75	3.0	
Hays-Murphy	80	54.0	ZDC[2] 50%, 54-113 km
RAYMODE X Coherent	80	3.5	ZDC 60%, 4-7.5 km; ZDC 20%, 19-45 km 100% coverage 13.5-15.5 km and 18.5-23 km
RAYMODE X Incoherent	80	12.0	100% coverage 56-57 km
Hays-Murphy	85	>200	Except for a few dropouts of ≤ 1 km
RAYMODE X Coherent	85	6.0	ZDC 60%, 6.5-50 km; ZDC 25%, 58.5-79.5 km; ZDC 10%, 104.5-115 km
RAYMODE X Incoherent	85	48	100% coverage 69-51.5 km
Hays-Murphy	90	>200	
RAYMODE X Coherent	90	8.0	ZDC 65%, 8-51 km; ZDC 55%, 55-124.5 km; ZDC 30%, 134.5-159km; ZDC 25%, 184-194.5 km
RAYMODE X Incoherent	90	118.5	100% coverage 136.5-140.5 km

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval for which detection is possible.

CONFIDENTIAL

(C) Table IIIB-8c. Detection Range in Kilometer as a Function of Figure of Merit (FOM) in dB for Hays-Murphy Mediterranean Experimental Data and RAYMODE X Model Predictions
Case III:
(Source Depth = 80 ft., Receiver Depth = 450 ft., Frequency = 100 Hz)
Bottom Loss: FNOC Type 3

Data Set	FOM	R_c[1]	Range > R_c
Hays-Murphy	75	17.5	ZDC[2] 60%, 17.5-42 km
RAYMODE X Coherent	75	2.5	Peaks at 5 and 10.5 km
RAYMODE X Incoherent	75	2.5	
Hays-Murphy	80	43.5	ZDC 20%, 43.5-84 km
RAYMODE X Coherent	80	3.0	ZDC 30%, 3.5-13 km; 100% coverage 23-27.5 km, 39-39.5 km, 45-46.5 km
RAYMODE X Incoherent	80	12.0	100% coverage 25-26 km
Hays-Murphy	85	127.5	ZDC 70%, 127.5-190 km
RAYMODE X Coherent	85	5.0	ZDC 65%, 5.5-54 km; ZDC 10%, 75-104 km Peak at 133 km
RAYMODE X Incoherent	85	48	100% coverage 69.5-71 km
Hays-Murphy	90	15.0	100% coverage except 15-18, 48-49, 161.5-180 and 190-199 km
RAYMODE X Coherent	90	6.0	ZDC 70%. 7-62 km; ZDC 50%, 65-145 km; ZDC 30%, 182-192.5 km; Peak at 150 km
RAYMODE X Incoherent	90	119	100% coverage 128-138 km

1. R_c = Range to which detection coverage is continuous.
2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval for which detection is possible.

CONFIDENTIAL

(C) Table IIIB-8d. Detection Range in Kilometer as a Function of Figure of Merit (FOM) in dB for Hays-Murphy Mediterranean Experimental Data and RAYMODE X Model Predictions
Case IV:
(Source Depth = 80 ft., Receiver Depth = 450 ft., Frequency = 200 Hz)
Bottom Loss: FNOC Type 3

Data Set	FOM	R_c [1]	Range > R_c
Hays-Murphy	75	21.5	ZDC[2] 90%, 21.5-37.5 km
RAYMODE X Coherent	75	2.0	
RAYMODE X Incoherent	75	2.0	
Hays-Murphy	80	42.5	ZDC 50%, 42.5-95 km
RAYMODE X Coherent	80	2.0	ZDC 5%, 3-44 km
RAYMODE X Incoherent	80	3.0	100% coverage 3-4 km
Hays-Murphy	85	194	
RAYMODE X Coherent	85	2.0	ZDC 35%, 2.5-48 km; peak at 66 km
RAYMODE X Incoherent	85	23.0	100% coverage 131-147 km
Hays-Murphy	90	>200	
RAYMODE X Coherent	90	2.0	ZDC 60%, 2.5-48.5 km; ZDC 30%, 55-101.5 km; ZDC 25%, 125-135.5 km; ZDC 30%, 163-167.5 km
RAYMODE X Incoherent	90	49.0	100% coverage 64-81 km, 84-87.5 km, 99.5-101.5 km

1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval for which detection is possible.

CONFIDENTIAL

(C) Table IIIB-8e. Detection Range in Kilometer as a Function of Figure of Merit (FOM) in dB for Hays-Murphy Mediterranean Experimental Data and RAYMODE X Model Predictions
Case V:
(Source Depth = 80 ft., Receiver Depth = 350 ft., Frequency = 35 Hz)
Bottom Loss: FNOC Type 3

Data Set	FOM	R_c [1]	Range > R_c
Hays-Murphy	75	25.5	ZDC[2] 50%, 25.5-47 km
RAYMODE X Coherent	75	4.0	100% coverage 9-10 km, 7.5-8 km
RAYMODE X Incoherent	75	4.0	
Hays-Murphy	80	55	ZDC 40%, 55-93 km
RAYMODE X Coherent	80	5.0	ZDC 35%, 6-23 km, ZDC 20%, 34-40.5 km
RAYMODE X Incoherent	80	11.0	
Hays-Murphy	85	118	ZDC 50%, 118-188 km
RAYMODE X Coherent	85	6.5	ZDC 40%, 7.5-53.5 km; ZDC 20%, 60-87.5 km
RAYMODE X Incoherent	85	48.0	
Hays-Murphy	90	>200	
RAYMODE X Coherent	90	6.5	ZDC 70%, 7.5-120 km; Peak at 136 km
RAYMODE X Incoherent	90	99	100% coverage 102-121 km, 127.5-128.5 km, 133-136 km, 140-143 km

1. R_c = Range to which detection coverage is continuous.
2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval for which detection is possible.

CONFIDENTIAL

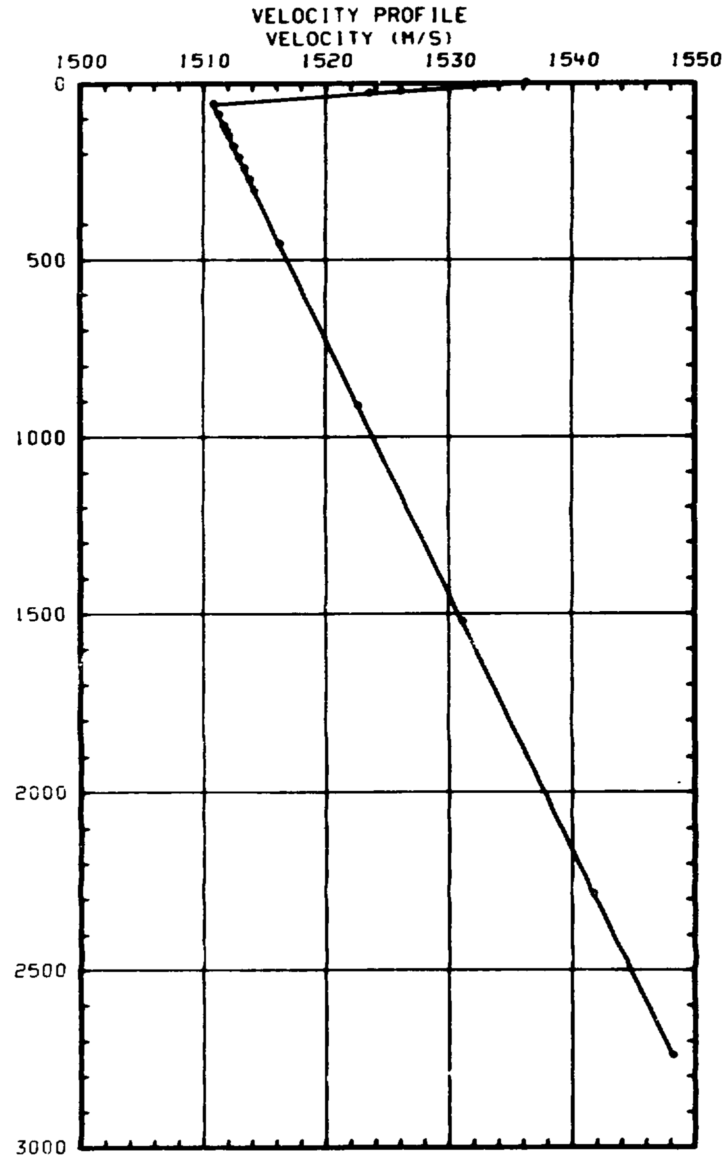
(C) Table IIIB-8f. Detection Range in Kilometer as a Function of Figure of Merit (FOM) in dB for Hays-Murphy Mediterranean Experimental Data and RAYMODE X Model Predictions
Case VI:
(Source Depth = 80 ft., Receiver Depth = 350 ft., Frequency = 100 Hz)
Bottom Loss: FNOC Type 3

Data Set	FOM	R_c [1]	Range > R_c
Hays-Murphy	75	17.0	ZDC[2] 10%, 17-41 km
RAYMODE X Coherent	75	2.5	Peaks at 4.0 and 11 km
RAYMODE X Incoherent	75	2.5	
Hays-Murphy	80	42.0	ZDC 10%, 42-52 km
RAYMODE X Coherent	80	3.0	ZDC 15%, 3.5-46 km
RAYMODE X Incoherent	80	2.5	100% coverage 3-8 km, 35-36 km
Hays-Murphy	85	54.0	ZDC 90%, 52-127 km
RAYMODE X Coherent	85	5.0	ZDC 30%, 6-55 km; ZDC 20%, 68-104 km Peaks at 137, 138, and 144 km
RAYMODE X Incoherent	85	47.5	100% coverage 68-70 km
Hays-Murphy	90	>200	
RAYMODE X Coherent	90	5.0	ZDC 60%, 5.5-60 km; ZDC 55%, 65-145 km ZDC 20%, 171-191.5 km
RAYMODE X Incoherent	90	119	100% coverage 128-139 km

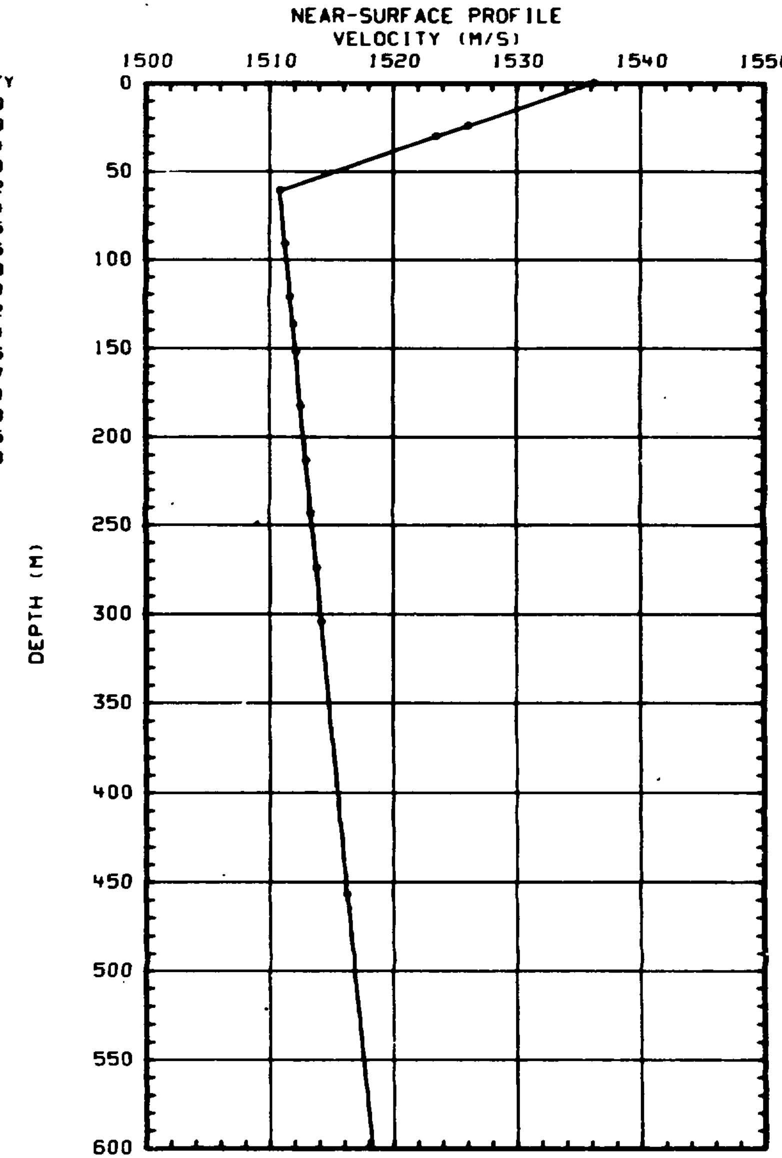
1. R_c = Range to which detection coverage is continuous.

2. ZDC = Zonal Detection Coverage in percentage of the indicated range interval for which detection is possible.

CONFIDENTIAL

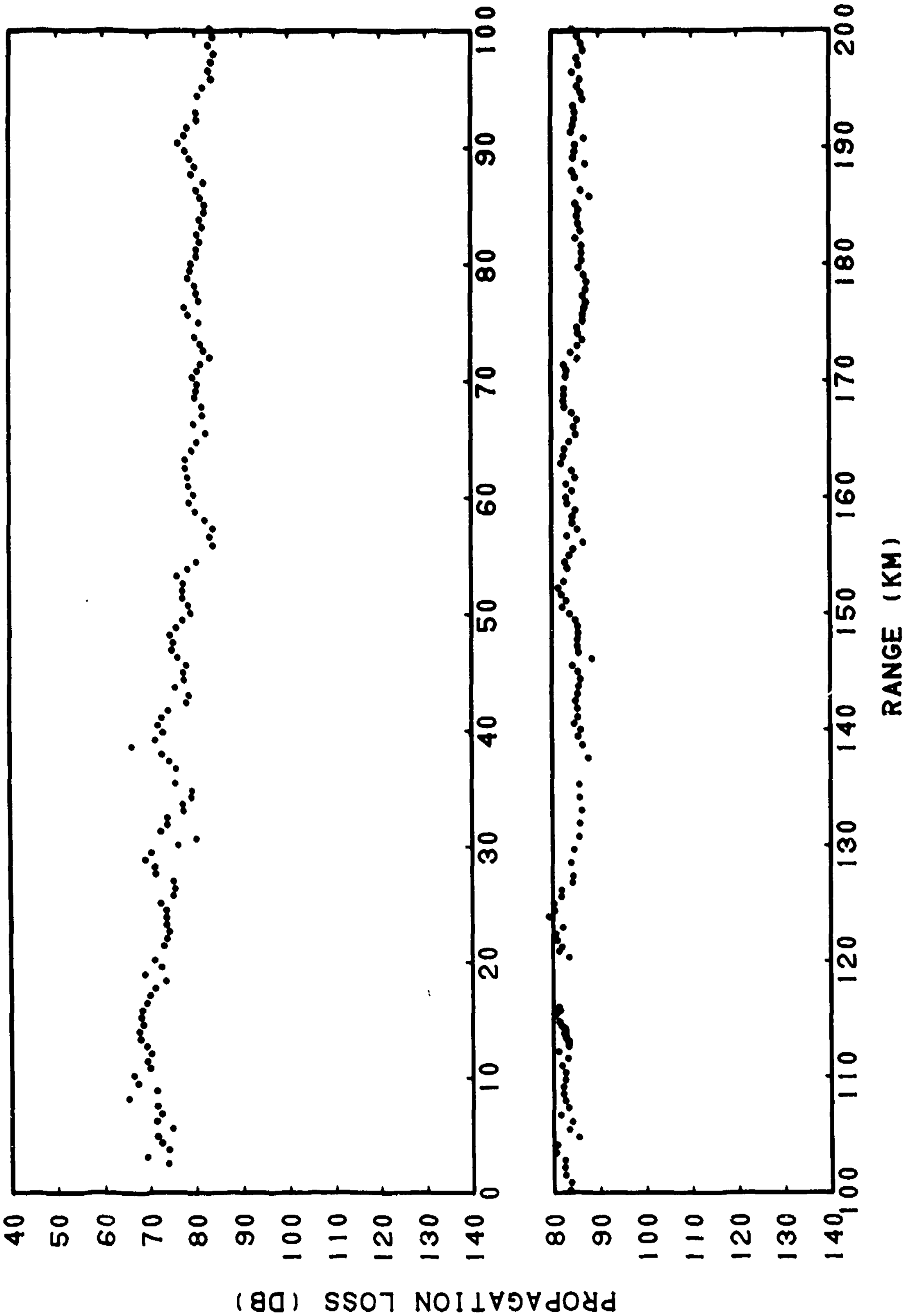


DEPTH	VELOCITY
0.0	1536.19
24.4	1525.99
30.5	1523.44
61.0	1510.80
91.4	1511.22
121.9	1511.64
137.2	1511.85
152.4	1512.06
182.9	1512.48
213.4	1512.90
243.8	1513.32
274.3	1513.74
304.8	1514.16
457.2	1516.27
914.4	1522.60
1524.0	1531.08
2286.0	1541.75
2743.0	1548.18



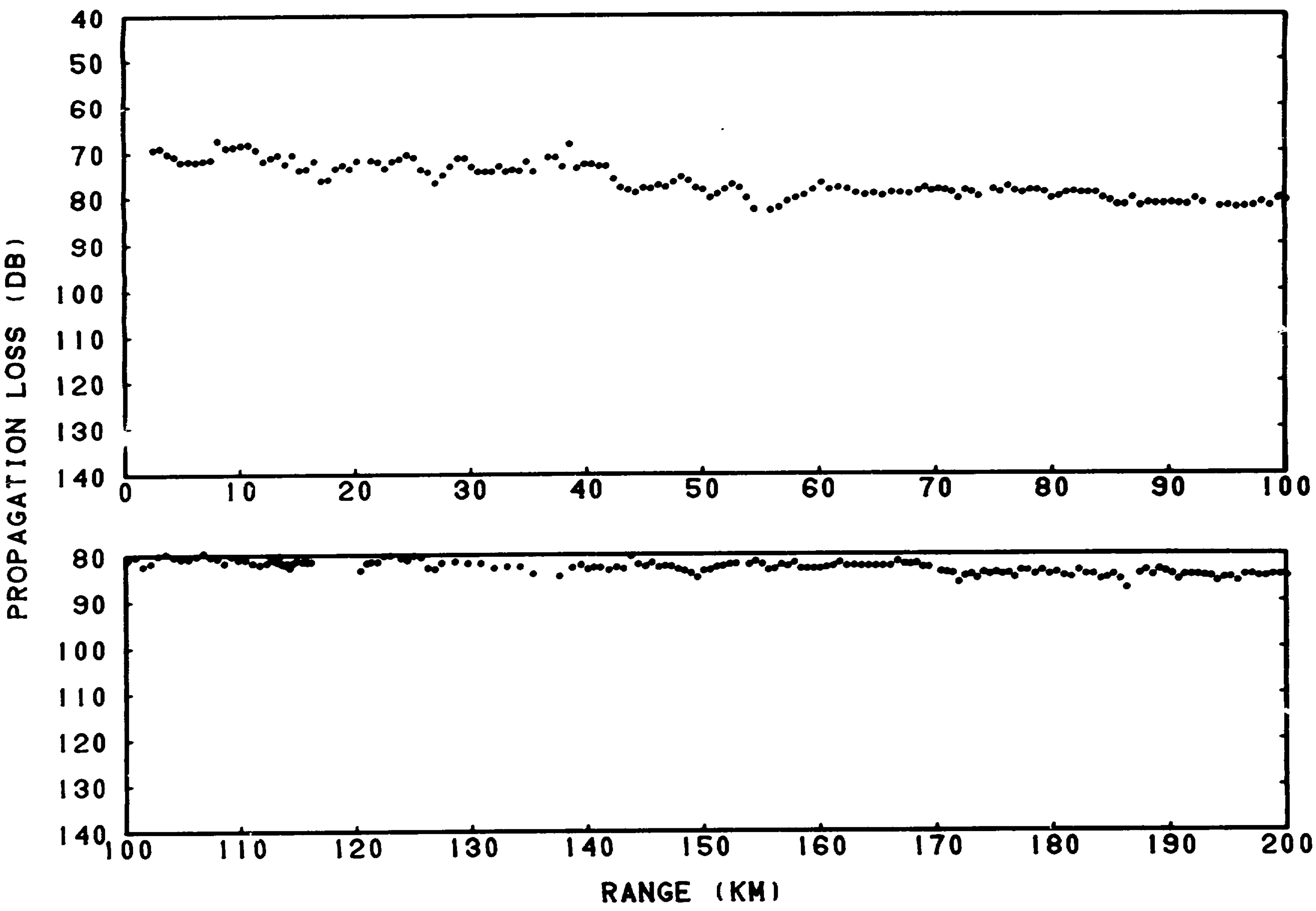
CONFIDENTIAL

(U) Figure IIIB-1. Hays-Murphy Mediterranean Experiment, Sound Speed Versus Depth Profile



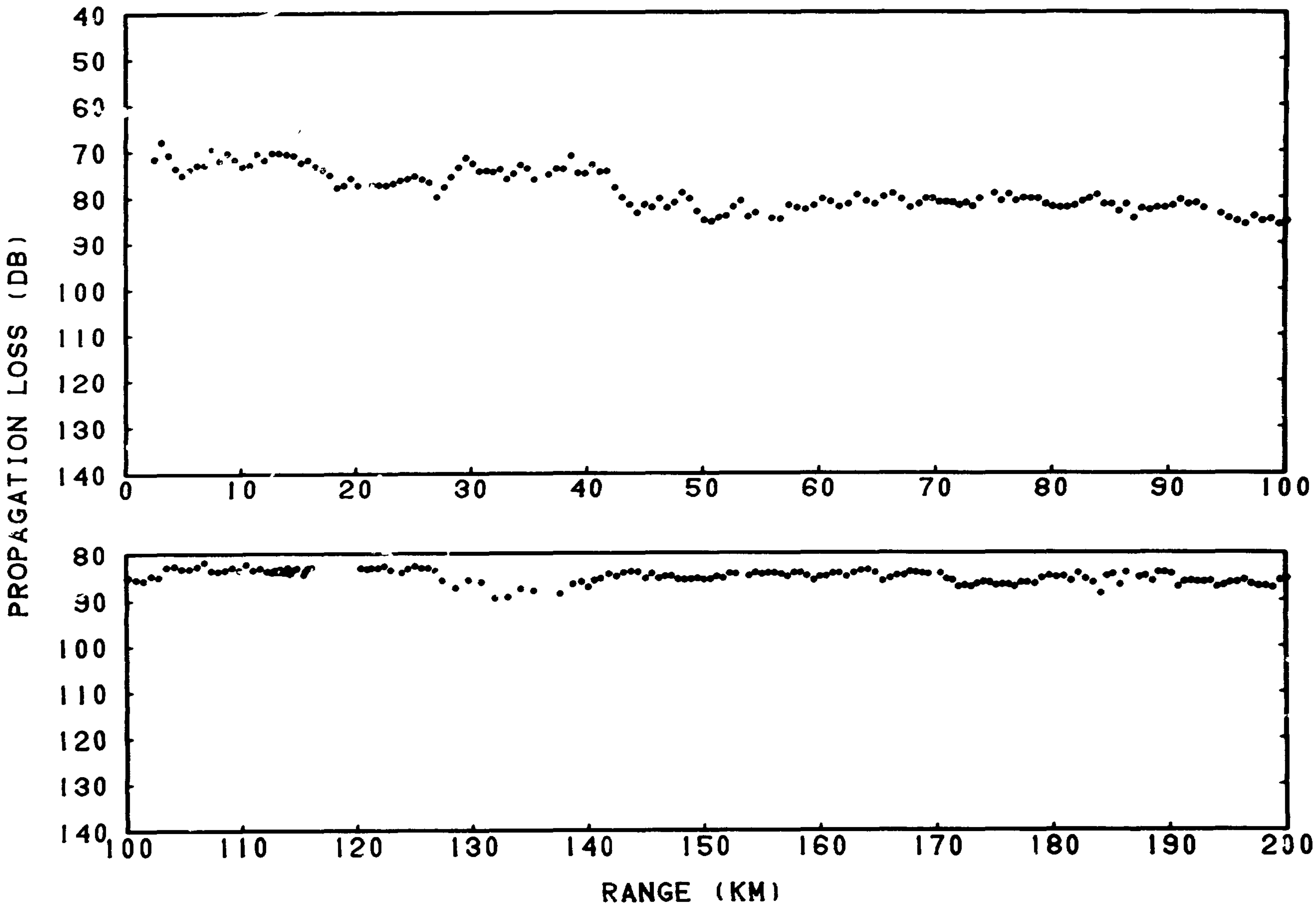
CONFIDENTIAL

(C) Figure IIIB-2. Hays-Murphy Experimental Data, Case 1, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 35 Hertz



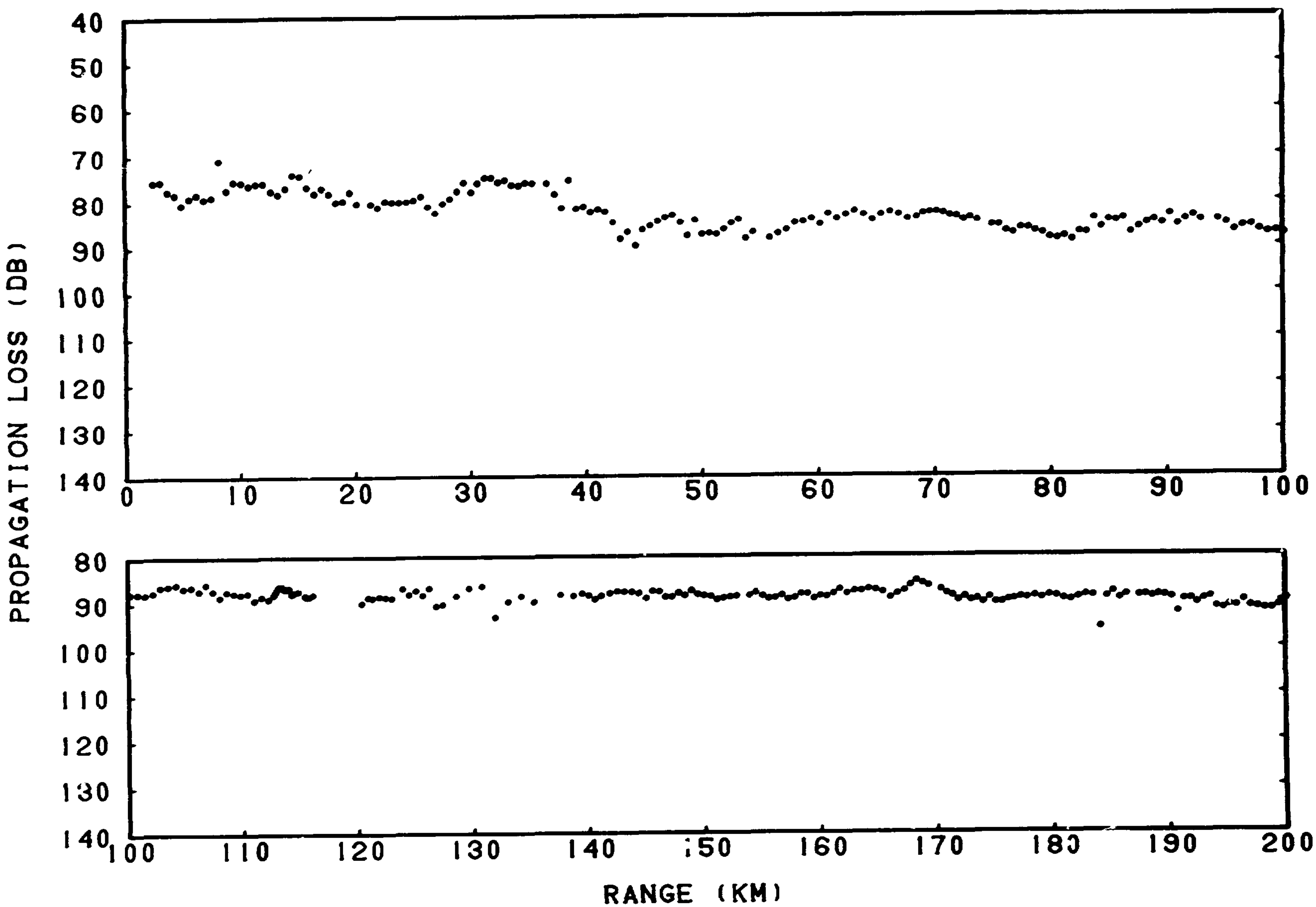
CONFIDENTIAL

(C) Figure IIIB-3. Hays-Murphy Experimental Data, Case II, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 67.5 Hertz



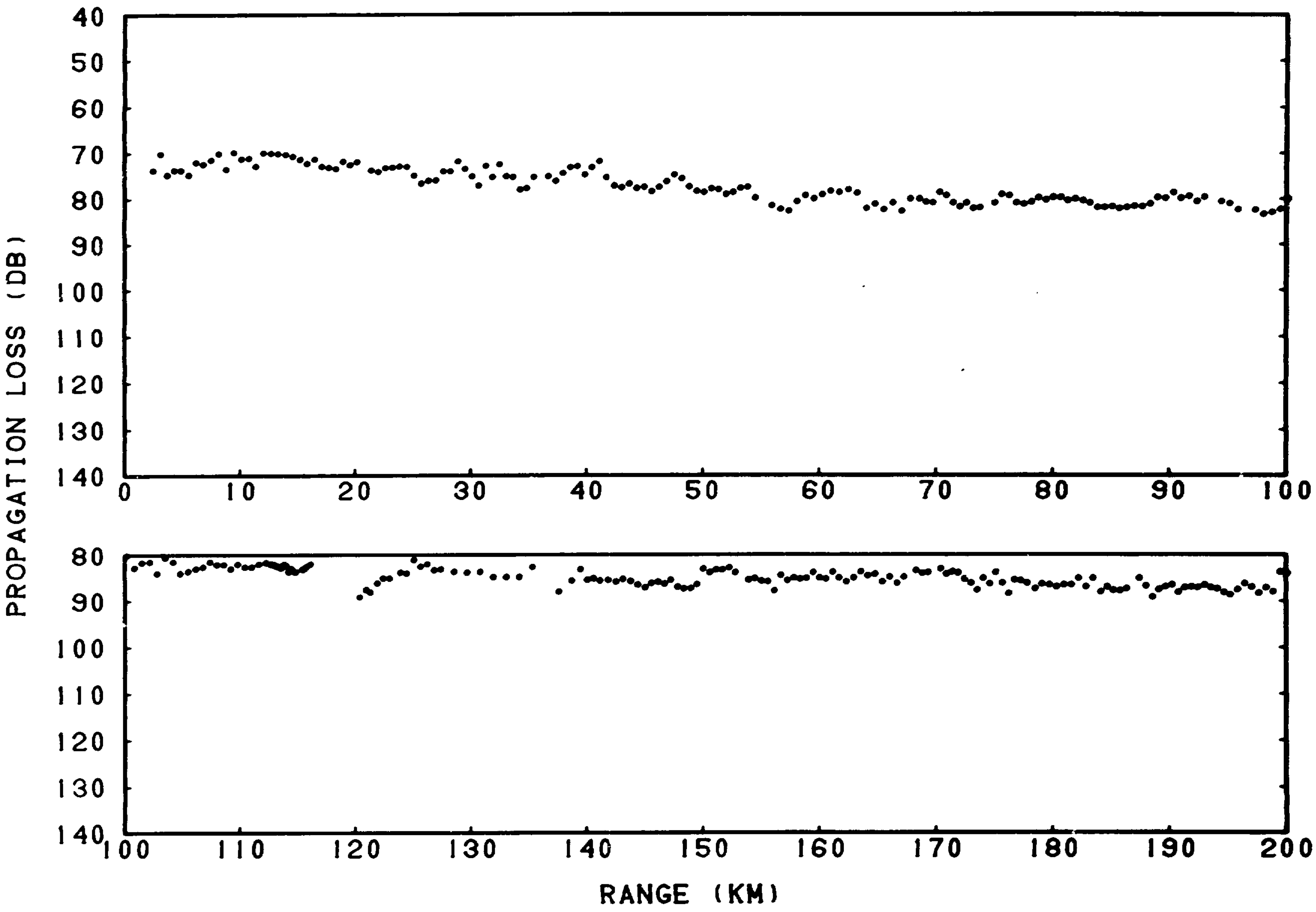
CONFIDENTIAL

(C) Figure IIIB-4. Hays-Murphy Experimental Data, Case III, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 100 Hertz



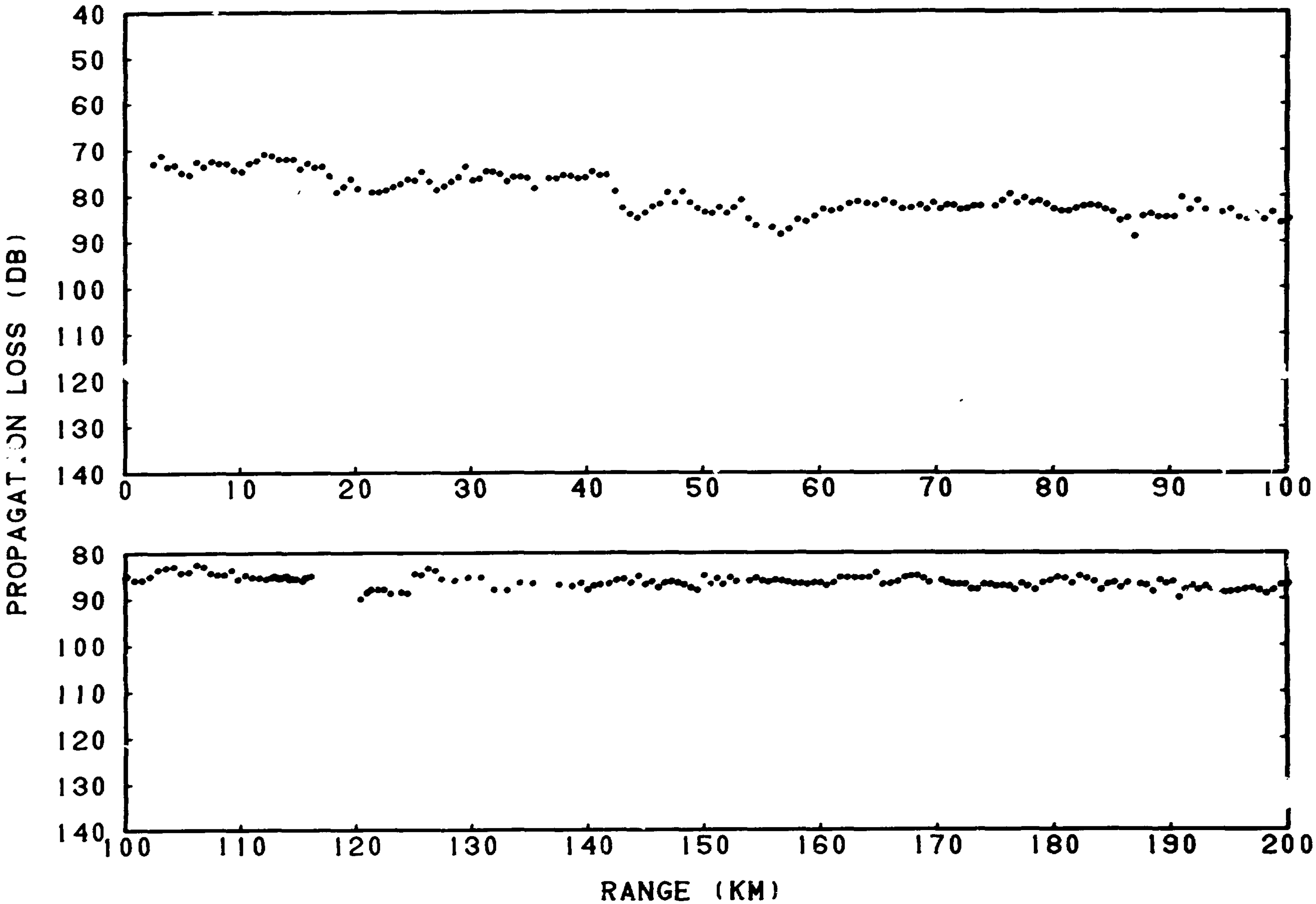
CONFIDENTIAL

(C) Figure IIIB-5. Hays-Murphy Experimental Data, Case IV, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 200 Hertz



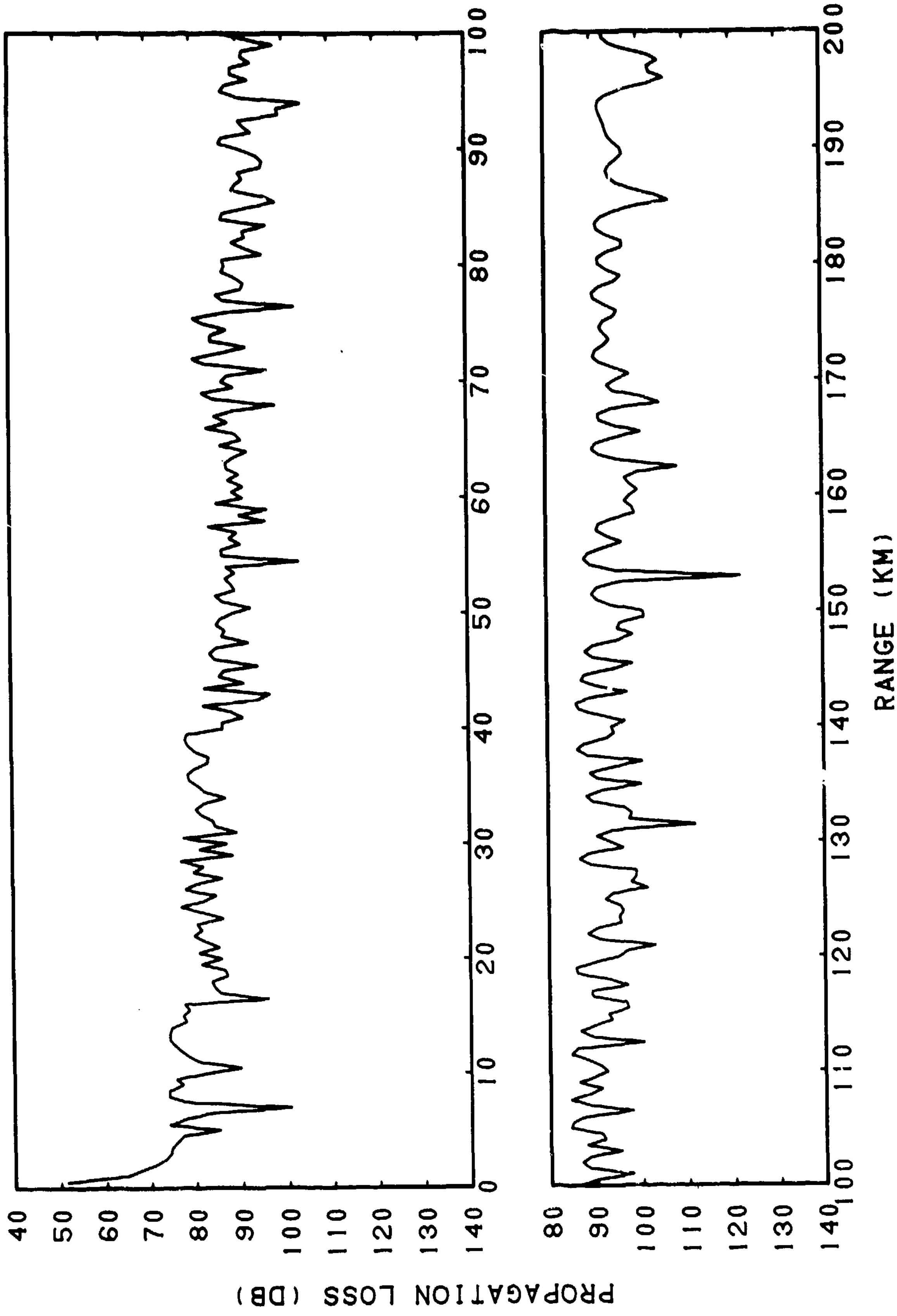
CONFIDENTIAL

(C) Figure IIIB-6. Hays-Murphy Experimental Data, CASE V, Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 35 Hertz



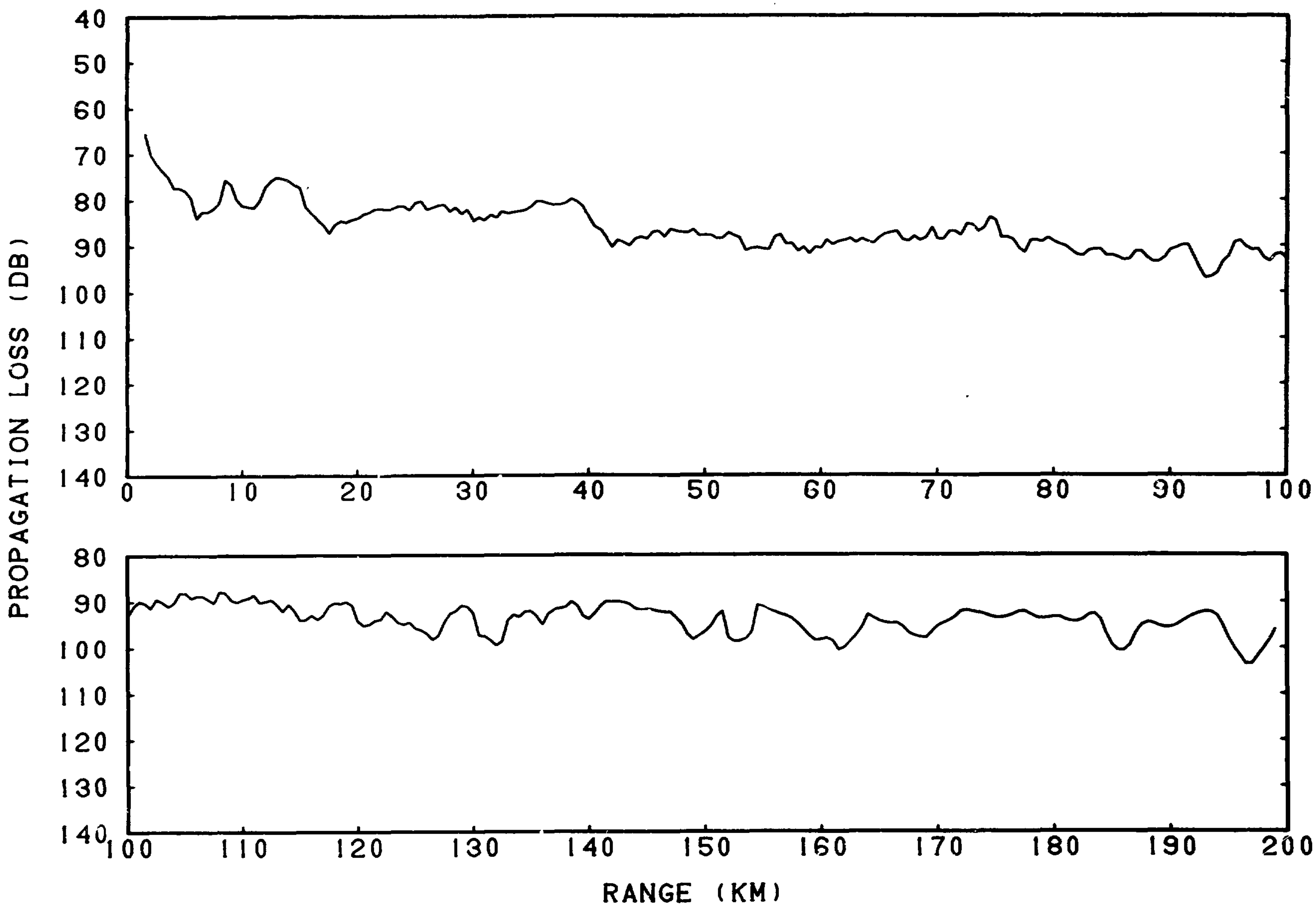
CONFIDENTIAL

(C) Figure IIIB-7. Hays-Murphy Experimental Data, Case VI, Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 100 Hertz



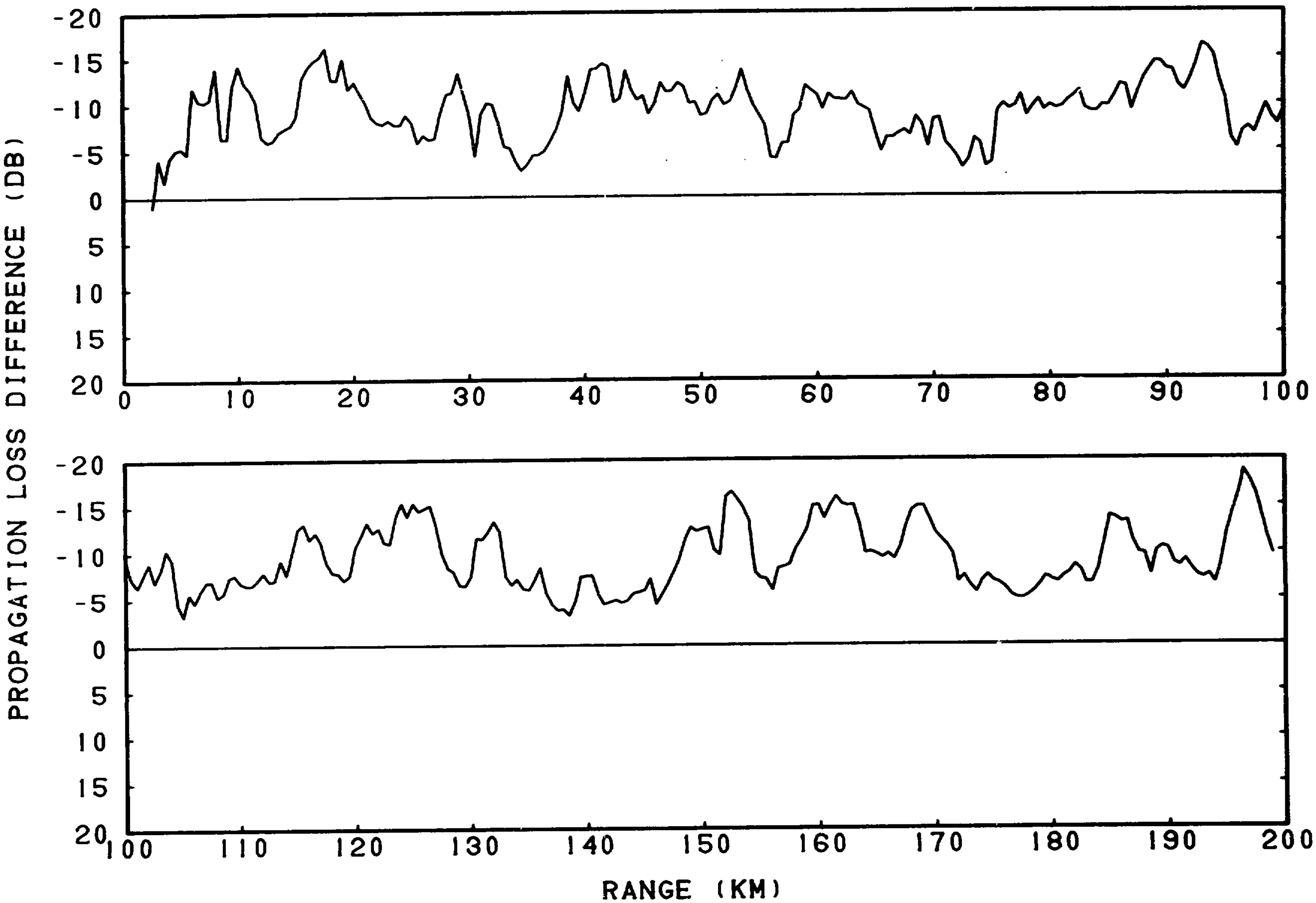
CONFIDENTIAL

(C) Figure IIIB-8. RAYMODE X (Coherent) Case I, Bottom Loss = MGS Type 2, Frequency = 35 Hertz



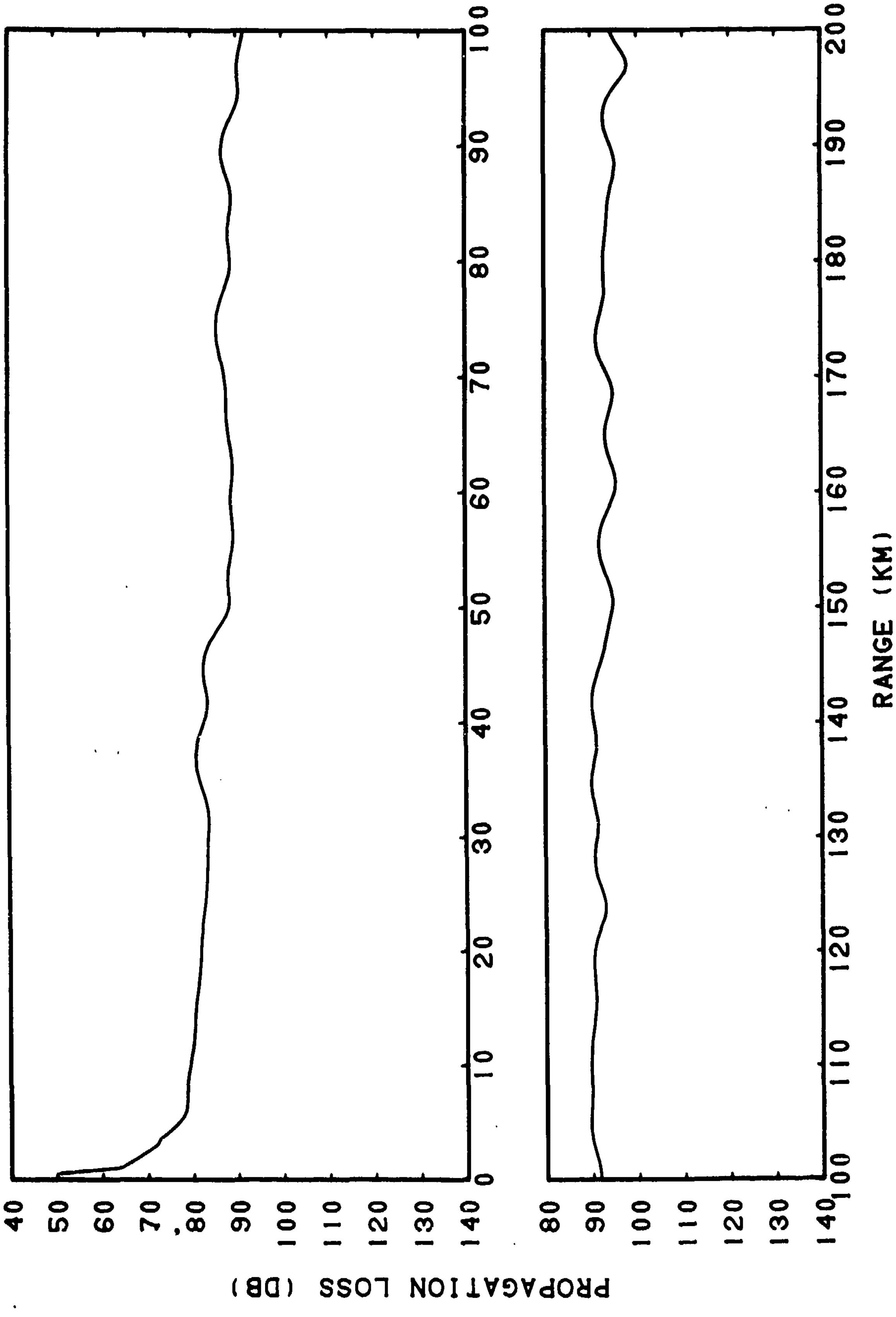
CONFIDENTIAL

(C) Figure IIIB-9. RAYMODE X (Coherent) Case I, Bottom Loss = MGS Type 2, Frequency = 35 Hertz, Sliding Averages of 5 Points (2.00 Kilometers)



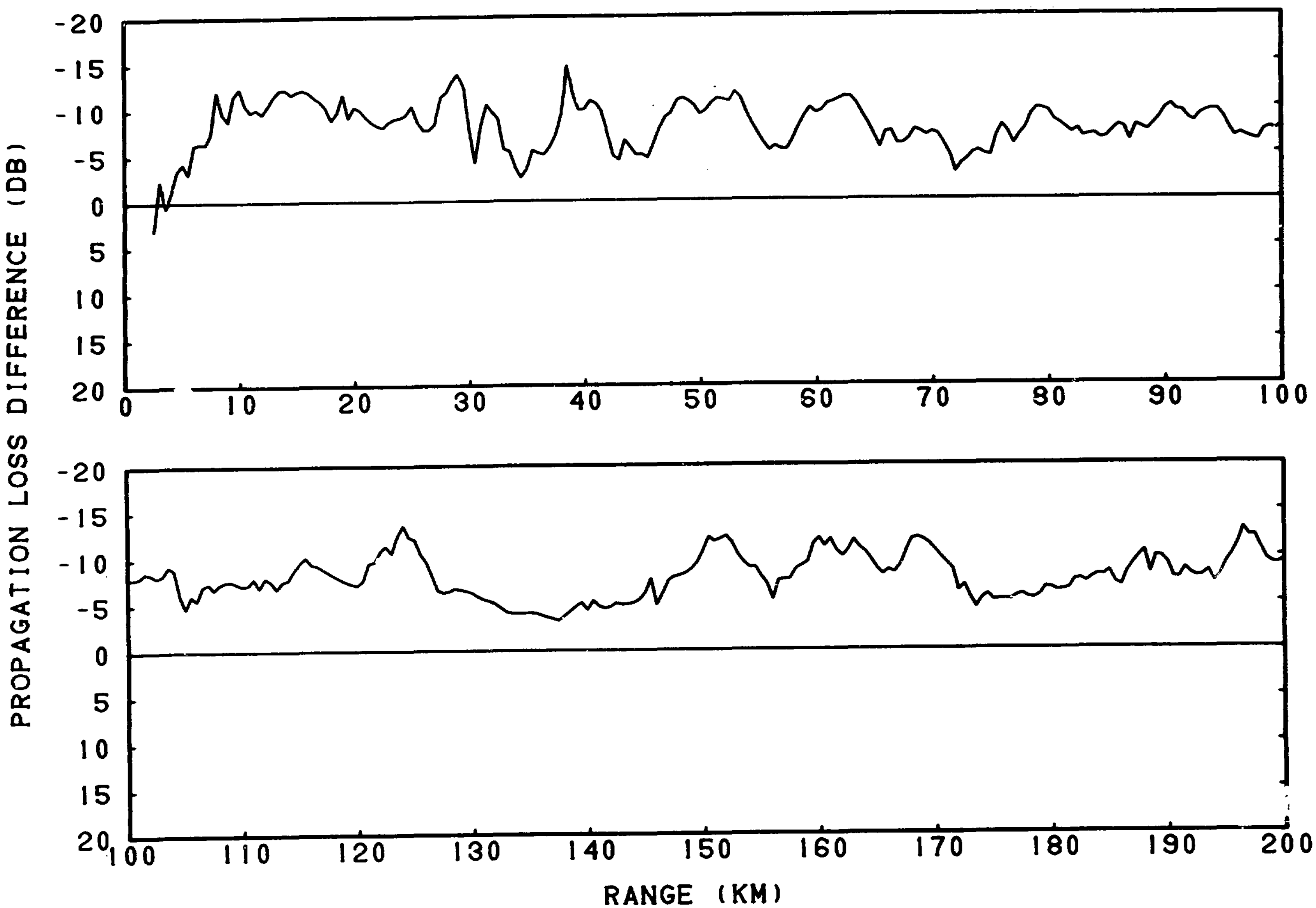
CONFIDENTIAL

(C) Figure IIIB-10. Smoothed RAYMODE X (Coherent) Case I, Bottom Loss = MGS Type 2, Frequency = 35 Hertz, Subtracted from Hays-Murphy Experimental Data, Case I, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 35 Hertz



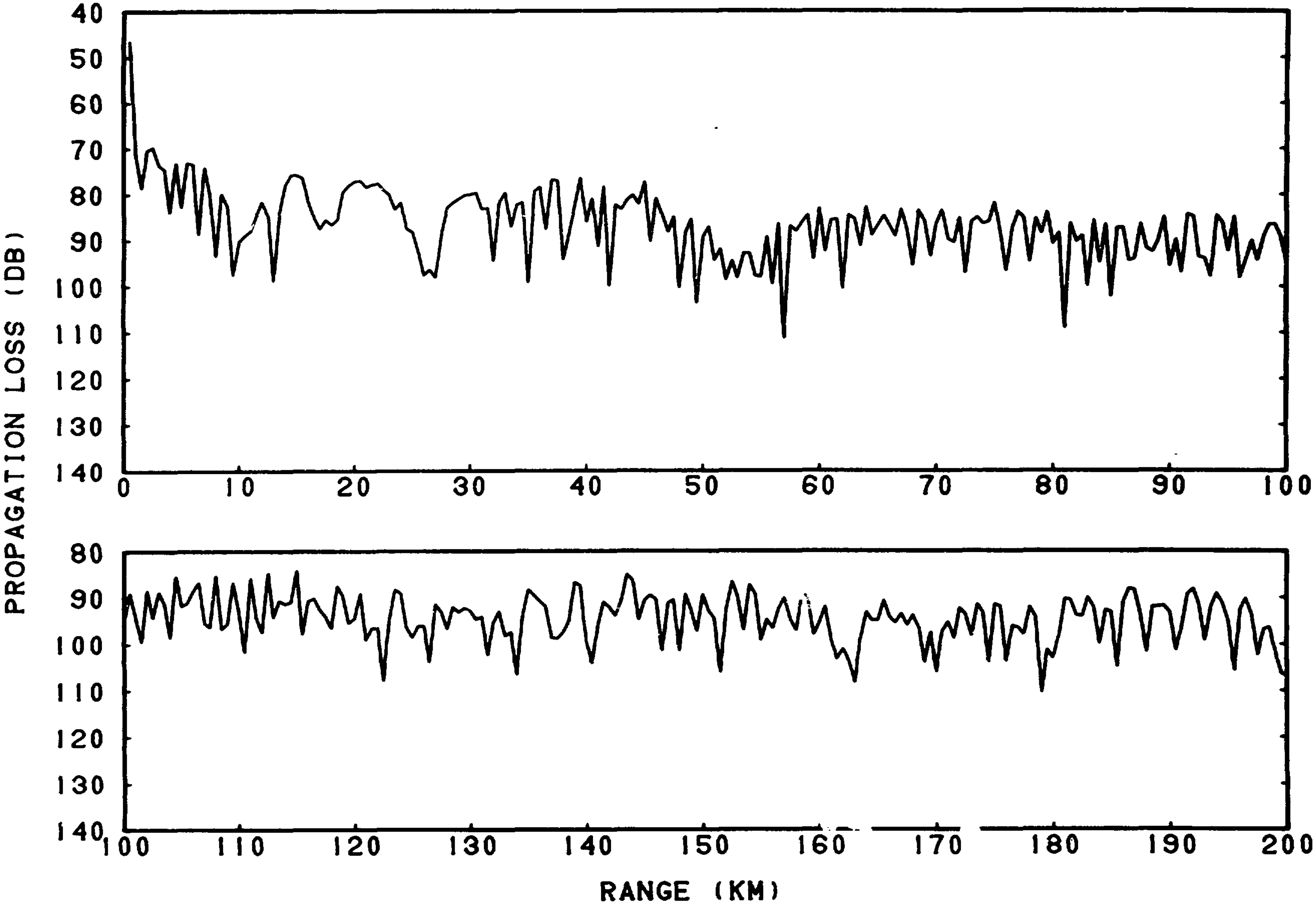
CONFIDENTIAL

(C) Figure IIIB-11. RAYMODE X (Incoherent) Case I, Bottom Loss = MGS Type 2, Frequency = 35 Hertz



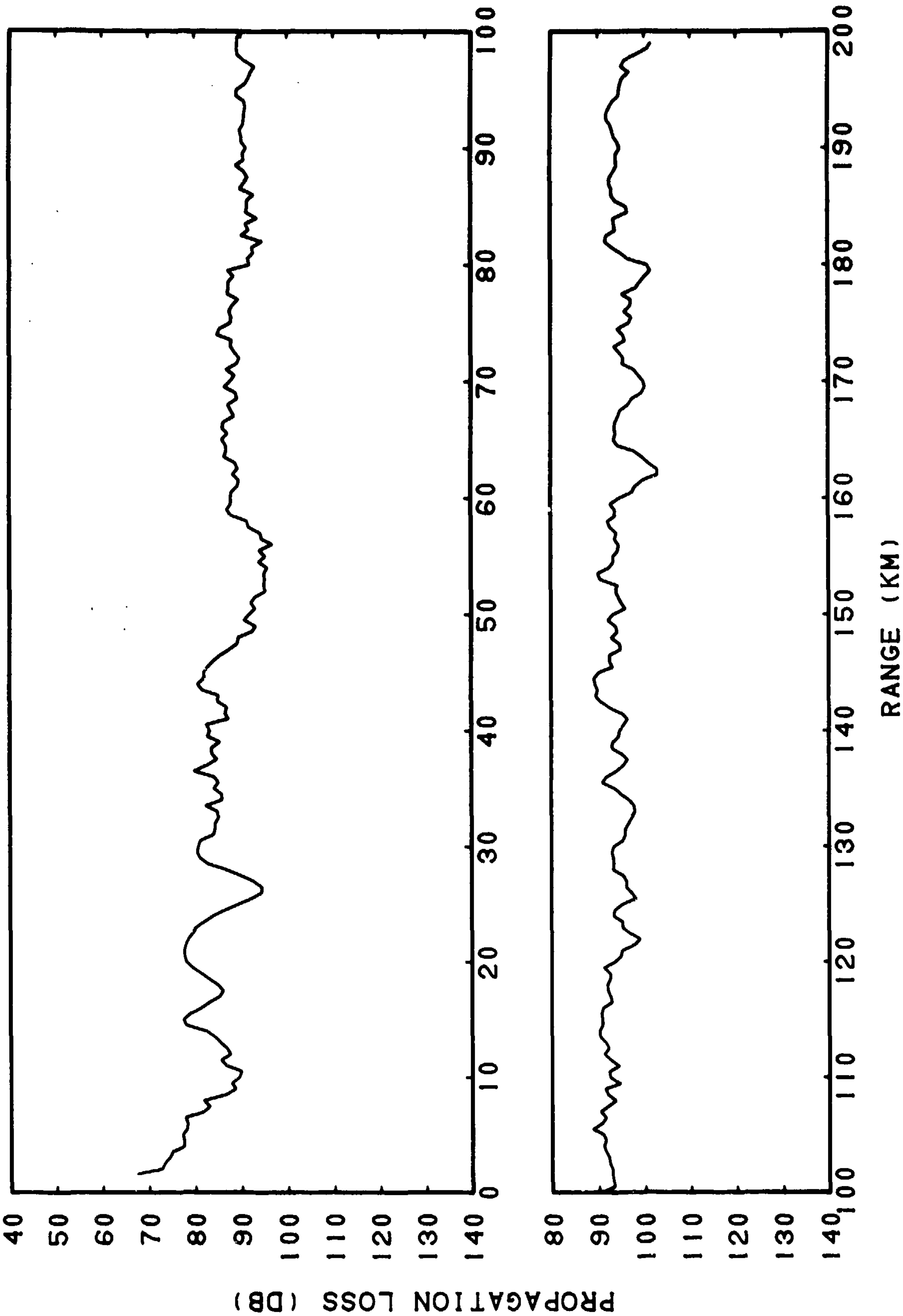
CONFIDENTIAL

(C) Figure IIIB-12. RAYMODE X (Incoherent) Case I, Bottom Loss = MGS Type 2, Frequency = 35 Hertz, Subtracted from Hays-Murphy Experimental Data, Case I, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 35 Hertz



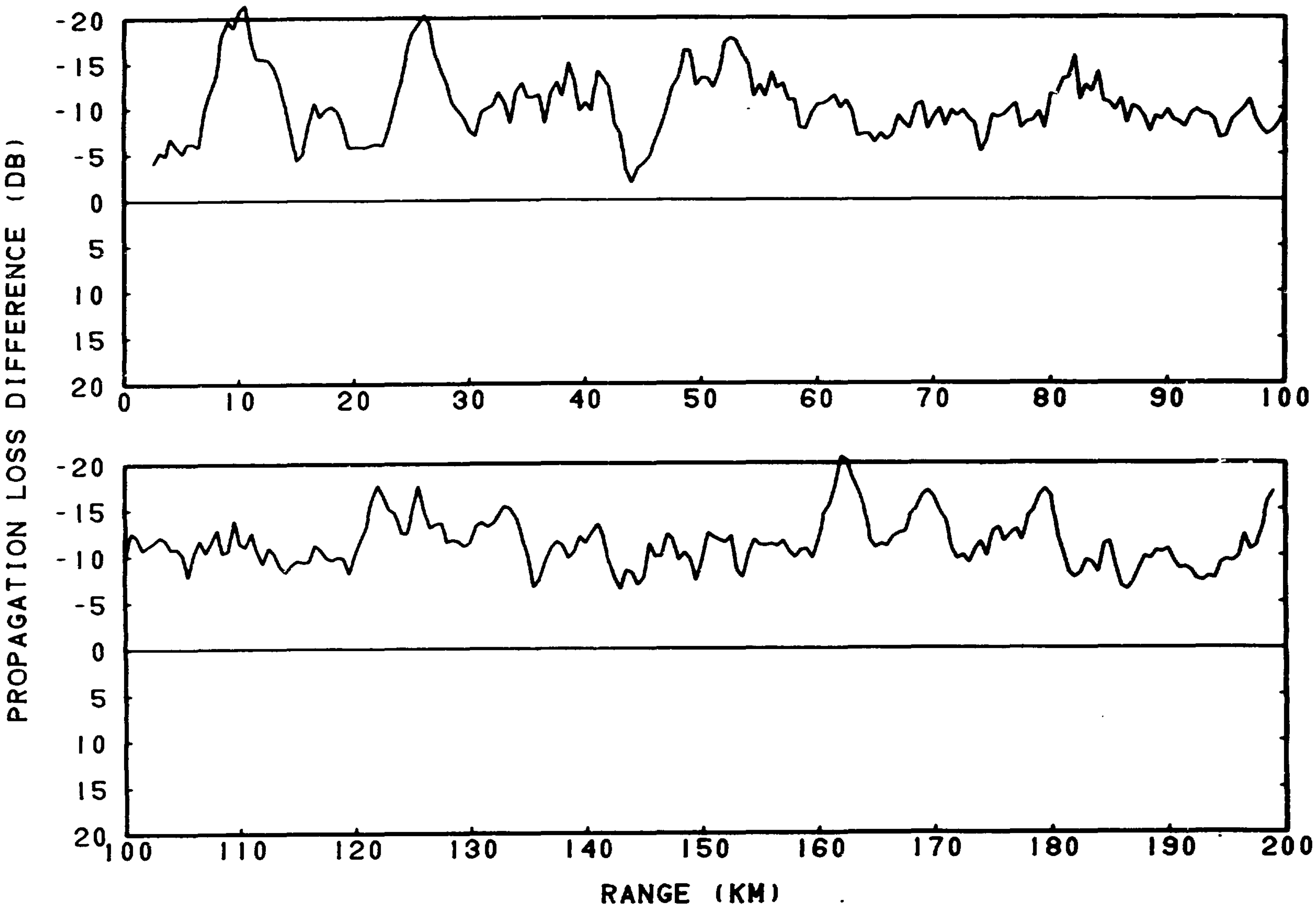
CONFIDENTIAL

(C) Figure IIIB-13. RAYMODE X (Coherent) Case II, Bottom Loss = MGS Type 2, Frequency = 67.5 Hertz



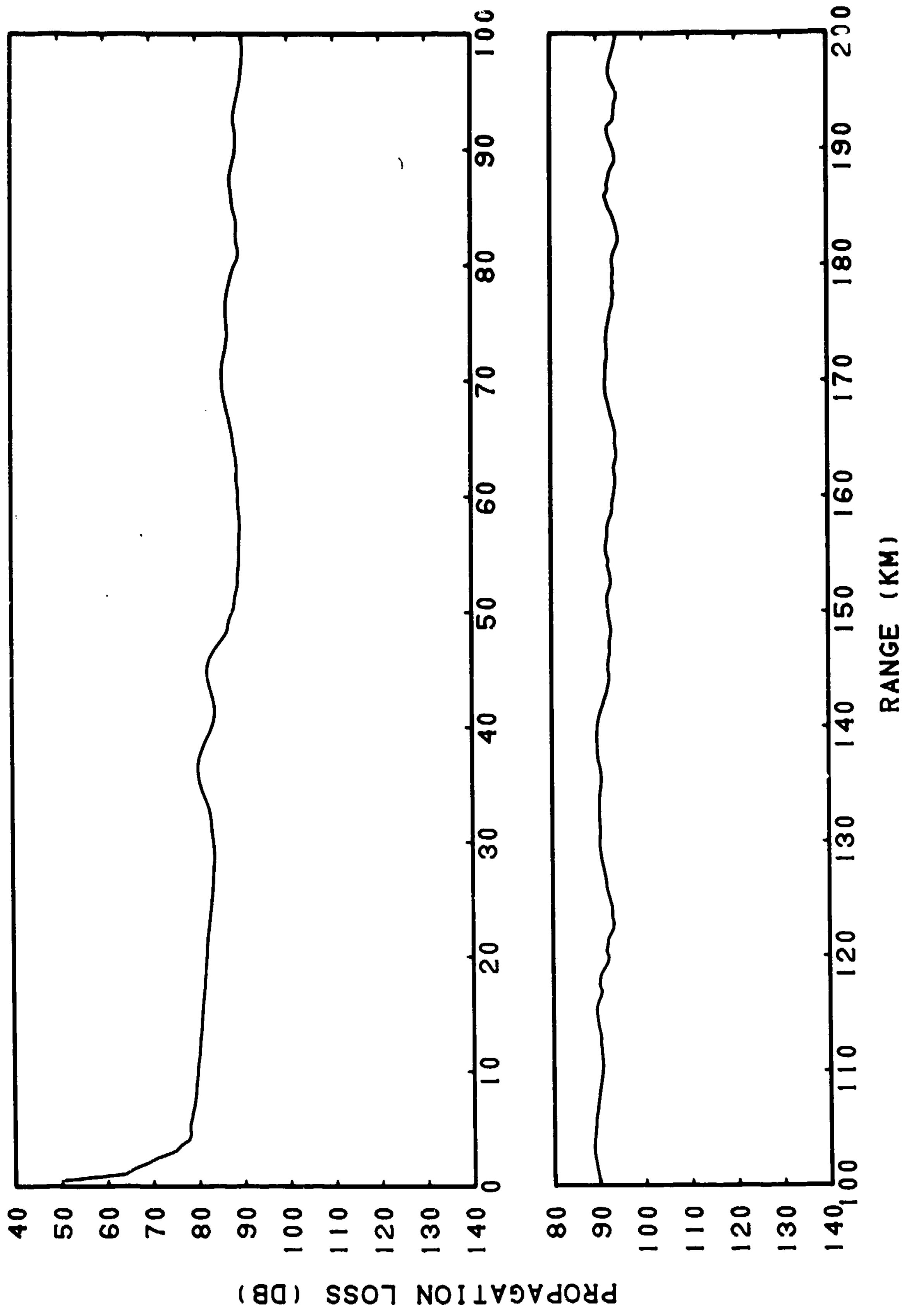
CONFIDENTIAL

(C) Figure IIIB-14. RAYMODE X (Coherent) Case II, Bottom Loss = MGS Type 2, Frequency = 67.5 Hertz, Sliding Averages of 5 Points (2.00 Kilometers)



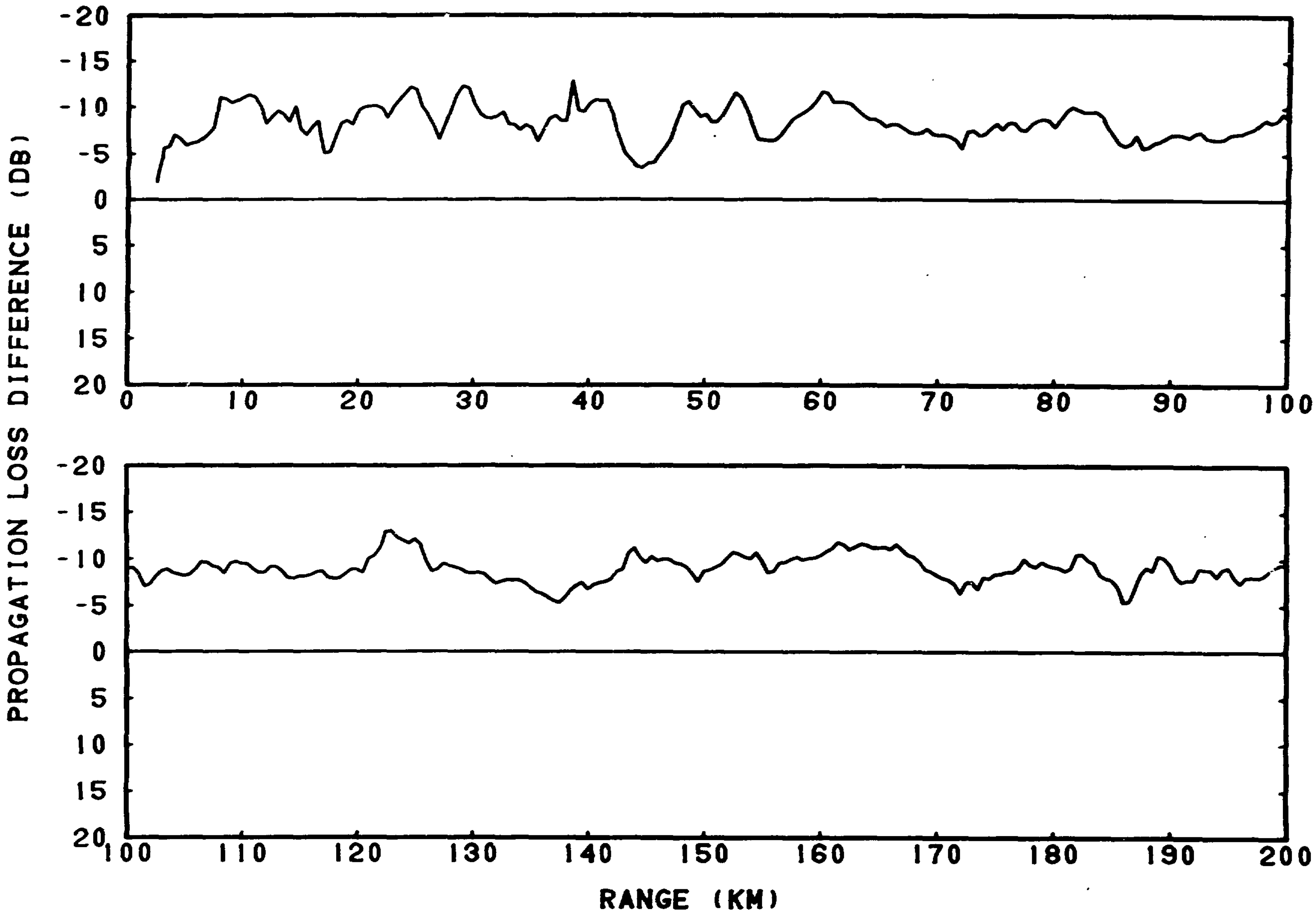
CONFIDENTIAL

(C) Figure IIIB-15. Smoothed RAYMODE X (Coherent) Case II, Bottom Loss = MGS Type 2, Frequency = 67.5 Hertz, Subtracted from Hays-Murphy Experimental Data, Case II, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 67.5 Hertz



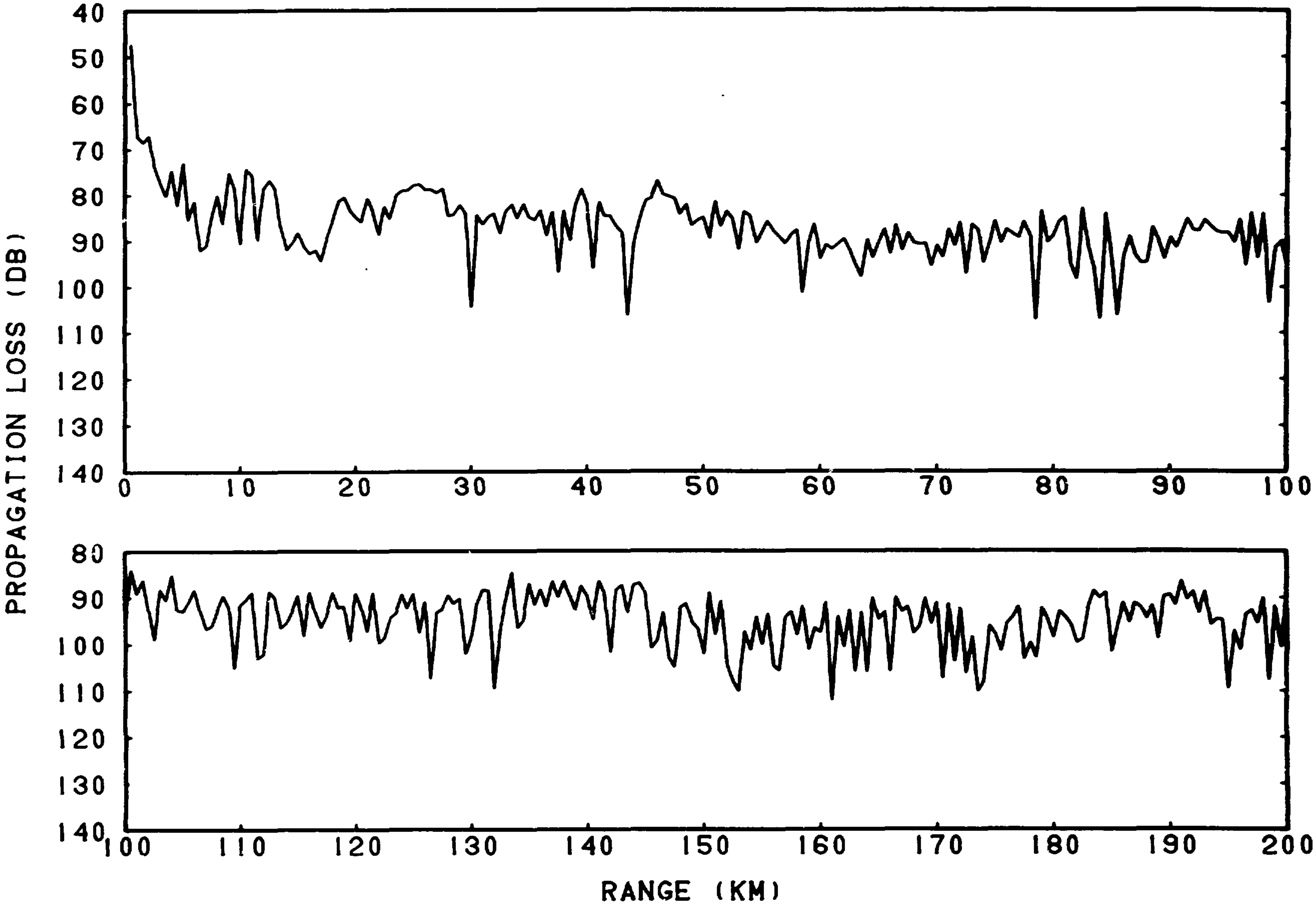
CONFIDENTIAL

(C) Figure IIIB-16. RAYMODE X (Incoherent) Case II, Bottom Loss = MGS Type 2, Frequency = 67.5 Hertz



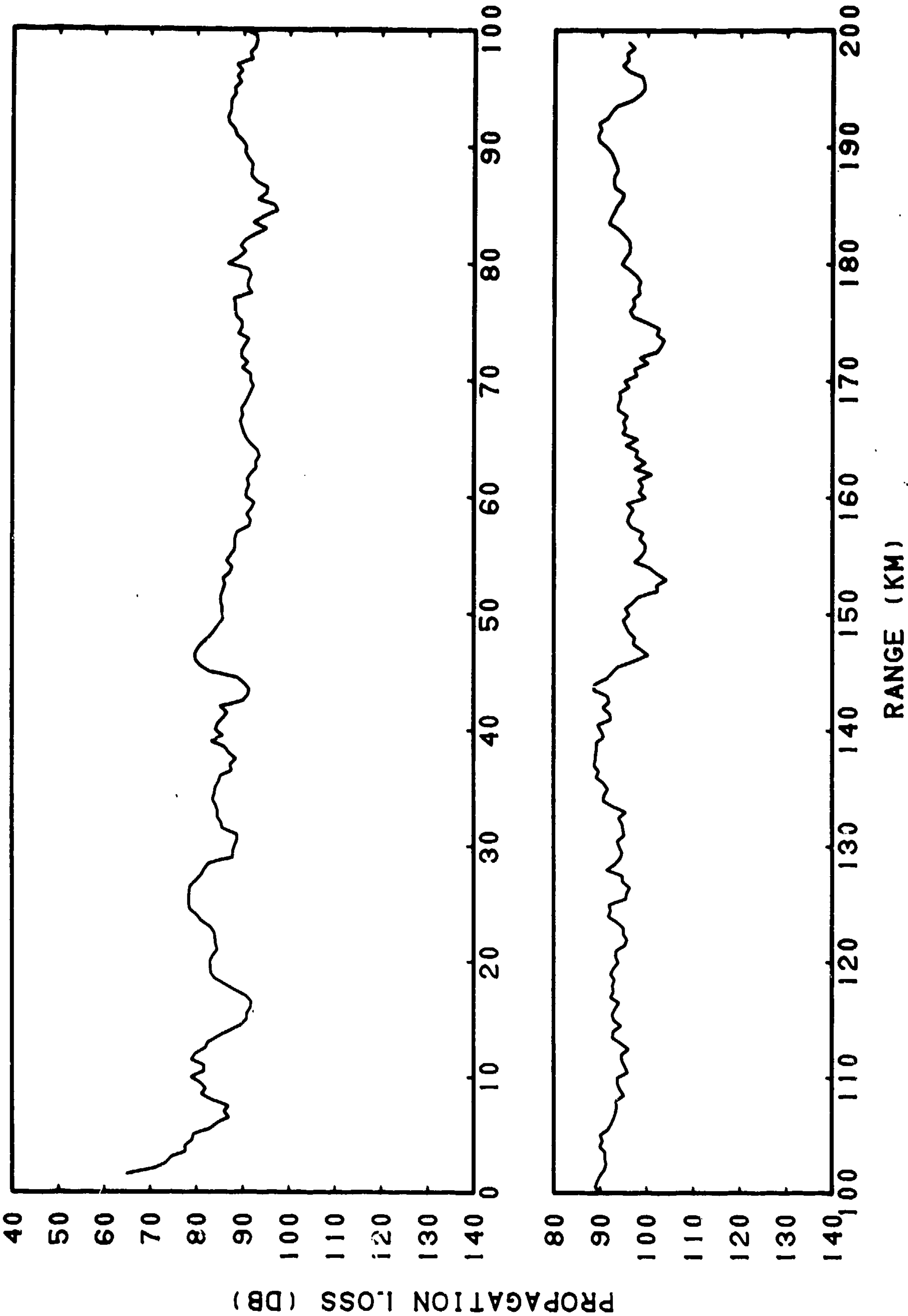
CONFIDENTIAL

(C) Figure IIIB-17. RAYMODE X (Incoherent) Case II, Bottom Loss = MGS Type 2, Frequency = 67.5 Hertz, Subtracted from Hays-Murphy Experimental Data, Case II, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 67.5 Hertz



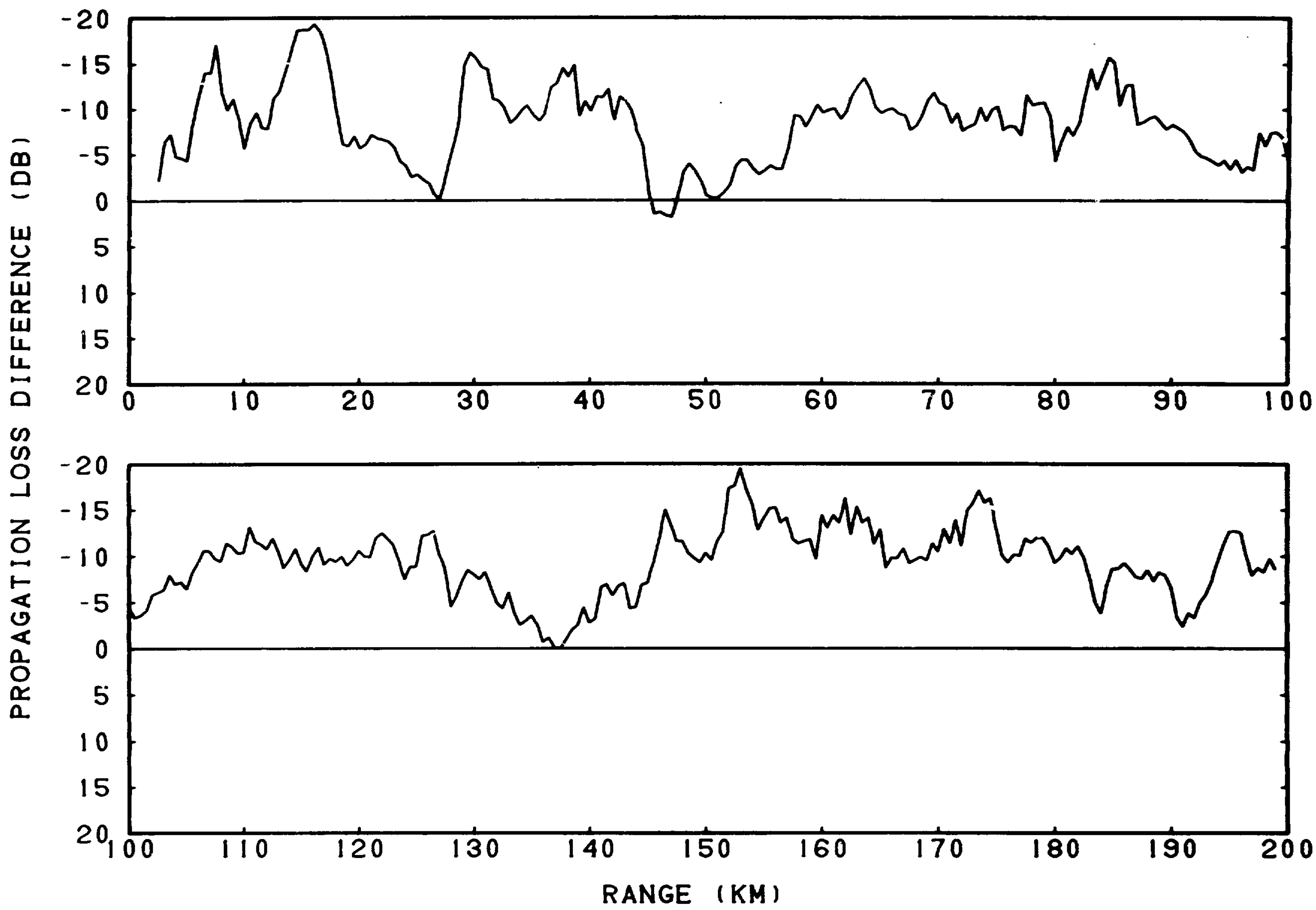
CONFIDENTIAL

(C) Figure IIIB-18. RAYMODE X (Coherent) Case III, Bottom Loss = MGS Type 2, Frequency = 100 Hertz



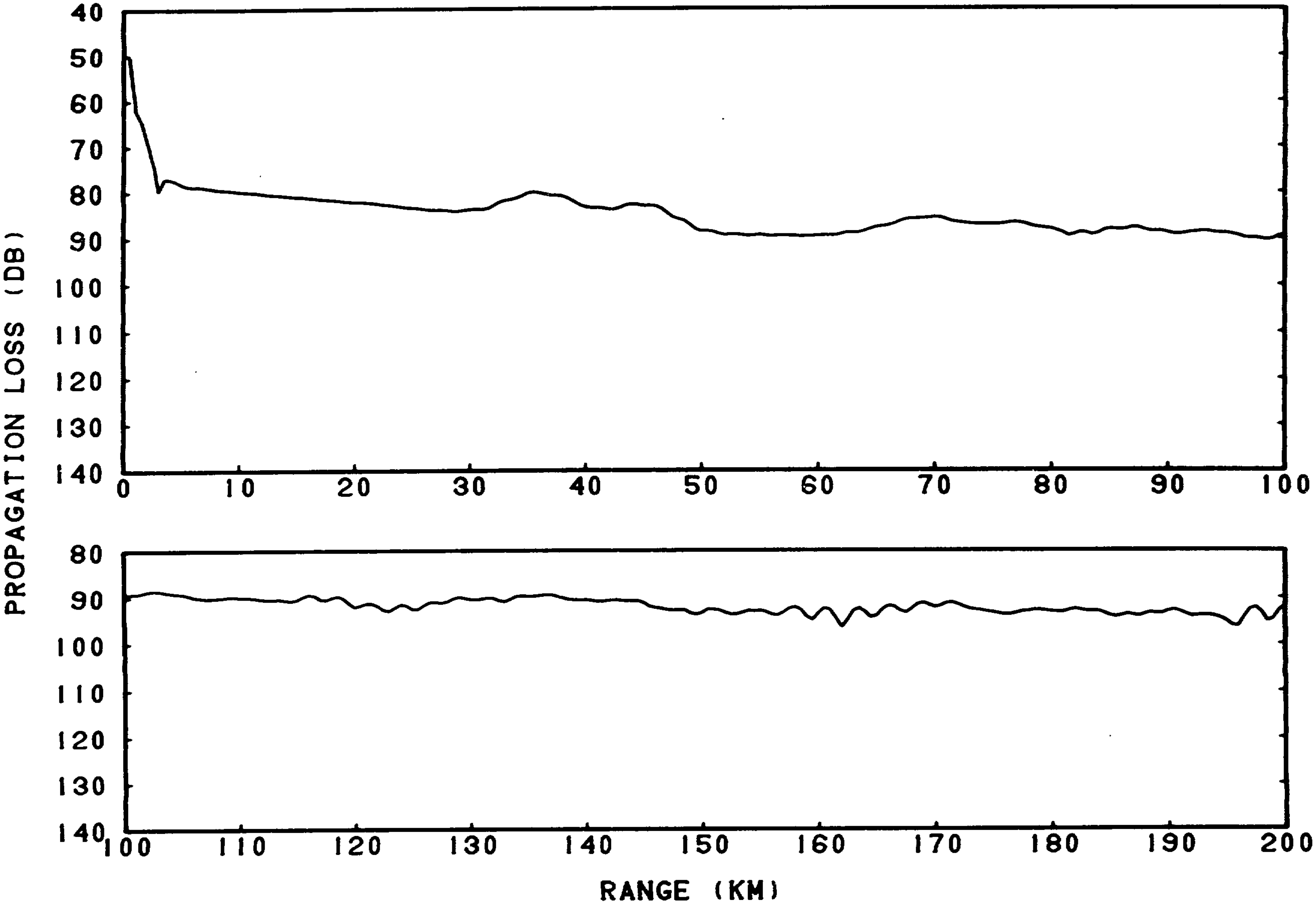
CONFIDENTIAL

(C) Figure IIIB-19. RAYMODE X (Coherent) Case III, Bottom Loss = MGS Type 2, Frequency = 100 Hertz, Sliding Averages of 5 Points (2.00 Kilometers)



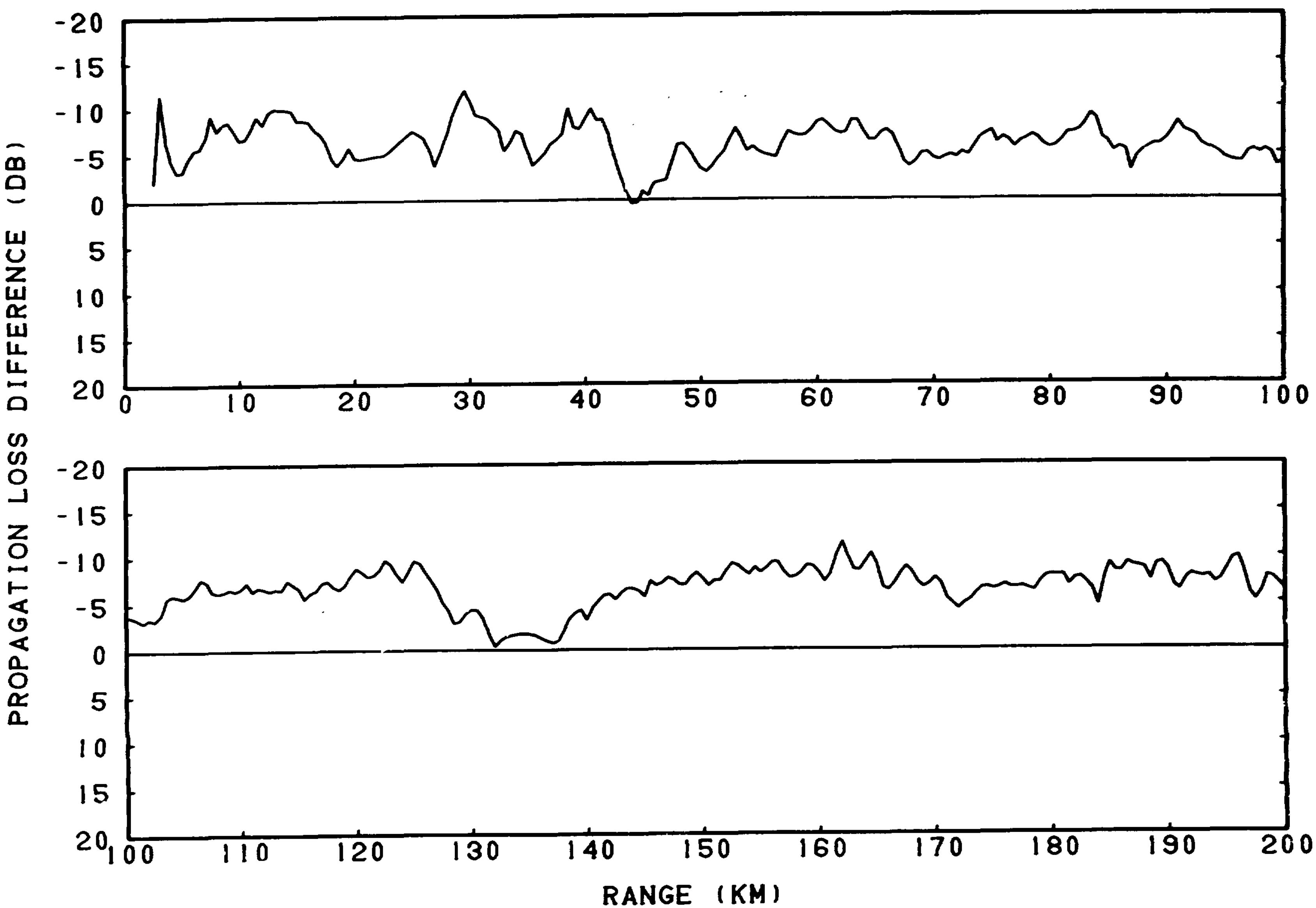
CONFIDENTIAL

(C) Figure IIIB-20. Smoothed RAYMODE X (Coherent) Case III, Bottom Loss = MGS Type 2, Frequency = 100 Hertz, Subtracted from Hays-Murphy Experimental Data, Case III, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 100 Hertz



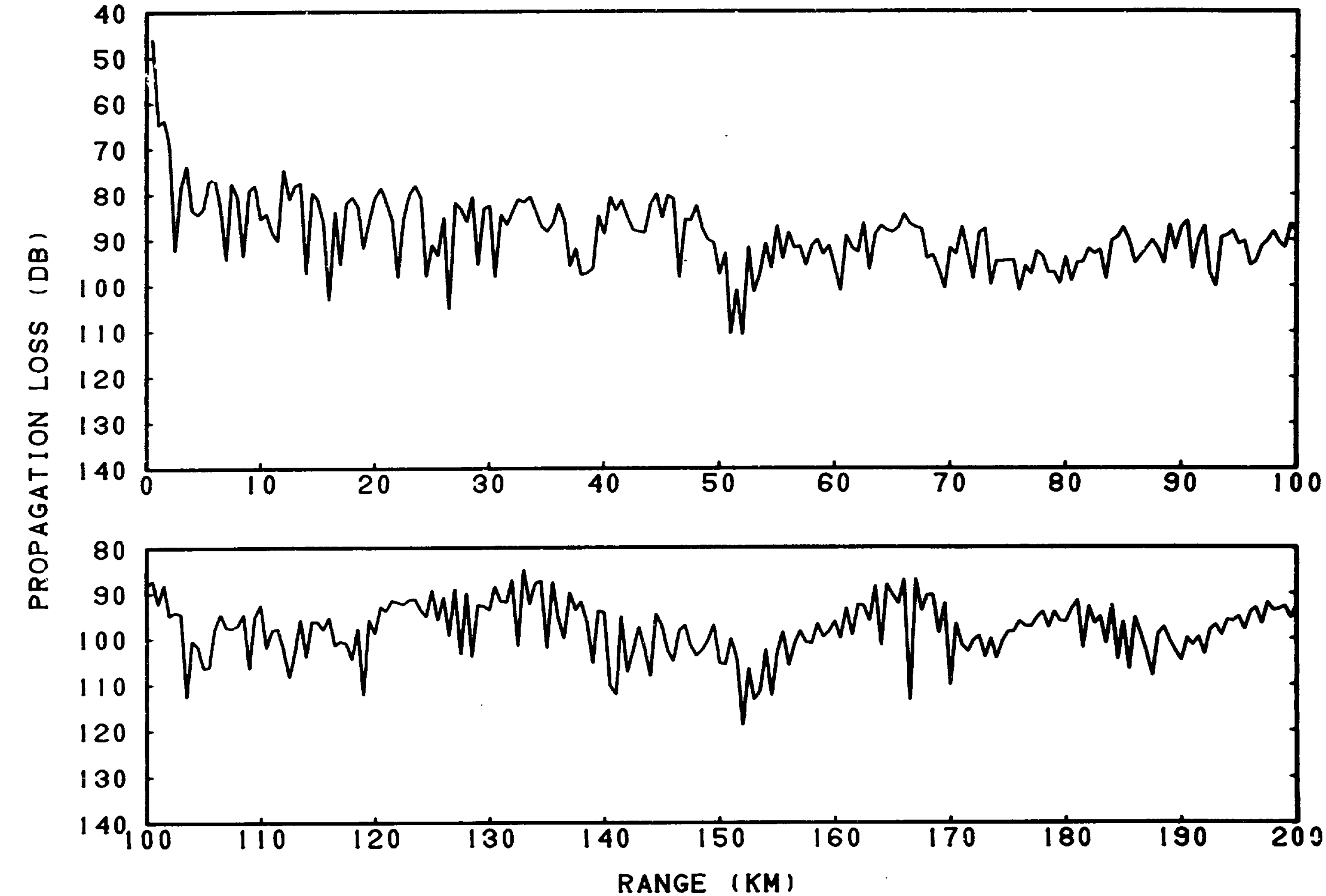
CONFIDENTIAL

(C) Figure IIIB-21. RAYMODE X (Incoherent) Case III, Bottom Loss = MGS Type 2, Frequency = 100 Hertz



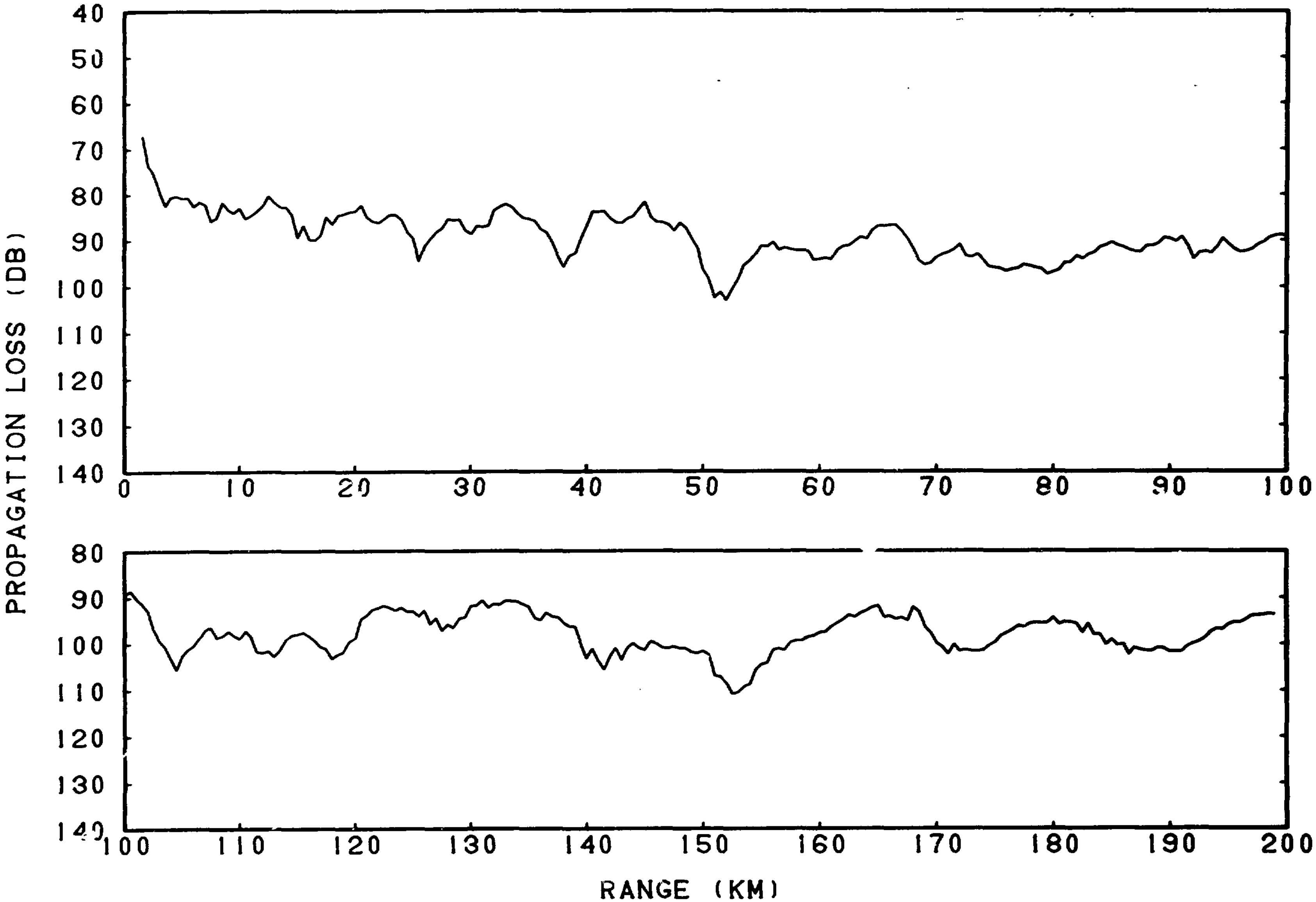
CONFIDENTIAL

(C) Figure IIIB-22. RAYMODE X (Incoherent) Case III, Bottom Loss = MGS Type 2, Frequency = 100 Hertz, Subtracted from Hays-Murphy Experimental Data, Case III, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 100 Hertz



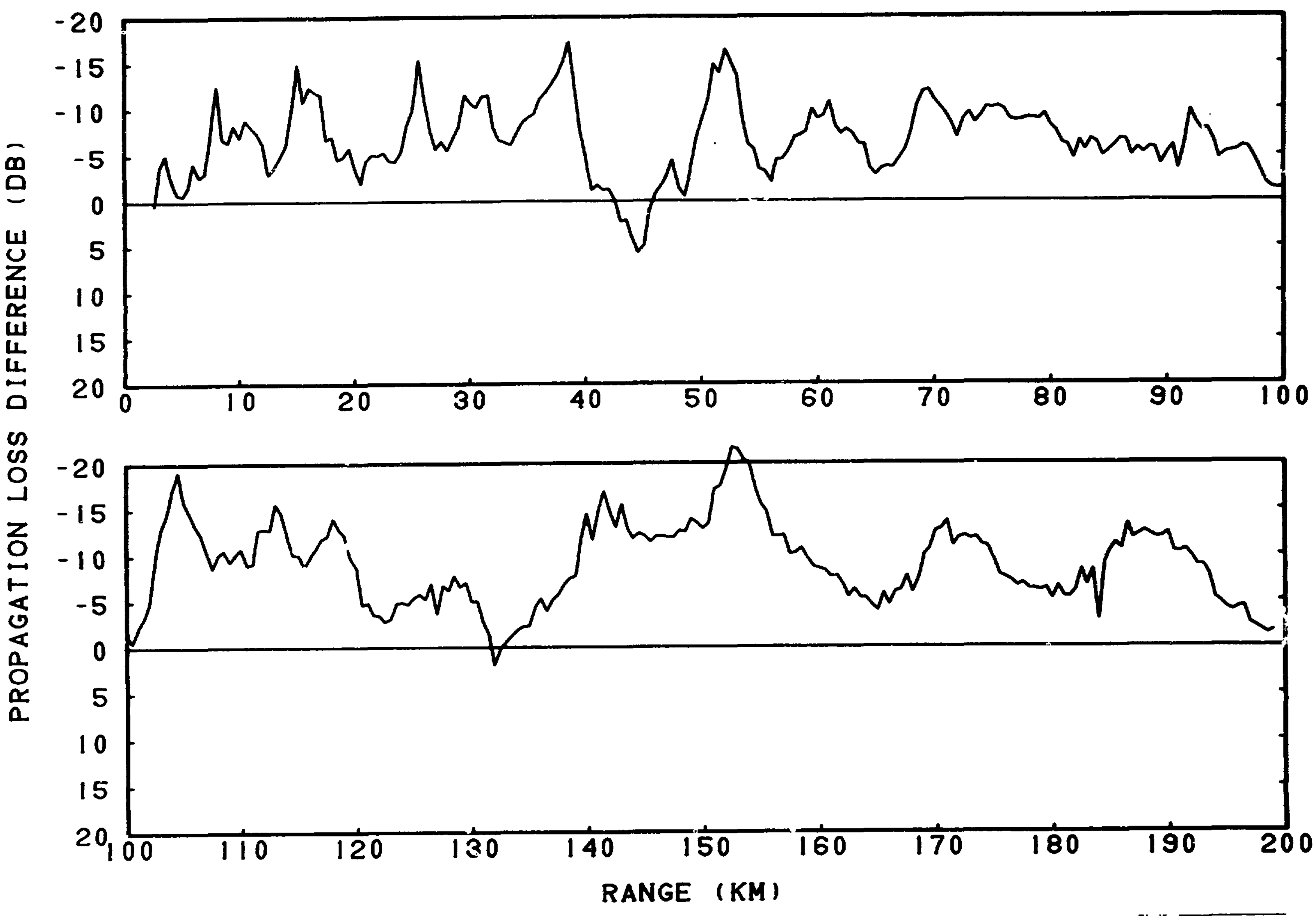
CONFIDENTIAL

(C) Figure IIIB-23. RAYMODE X (Coherent) Case IV, Bottom Loss = MGS Type 2, Frequency = 200 Hertz



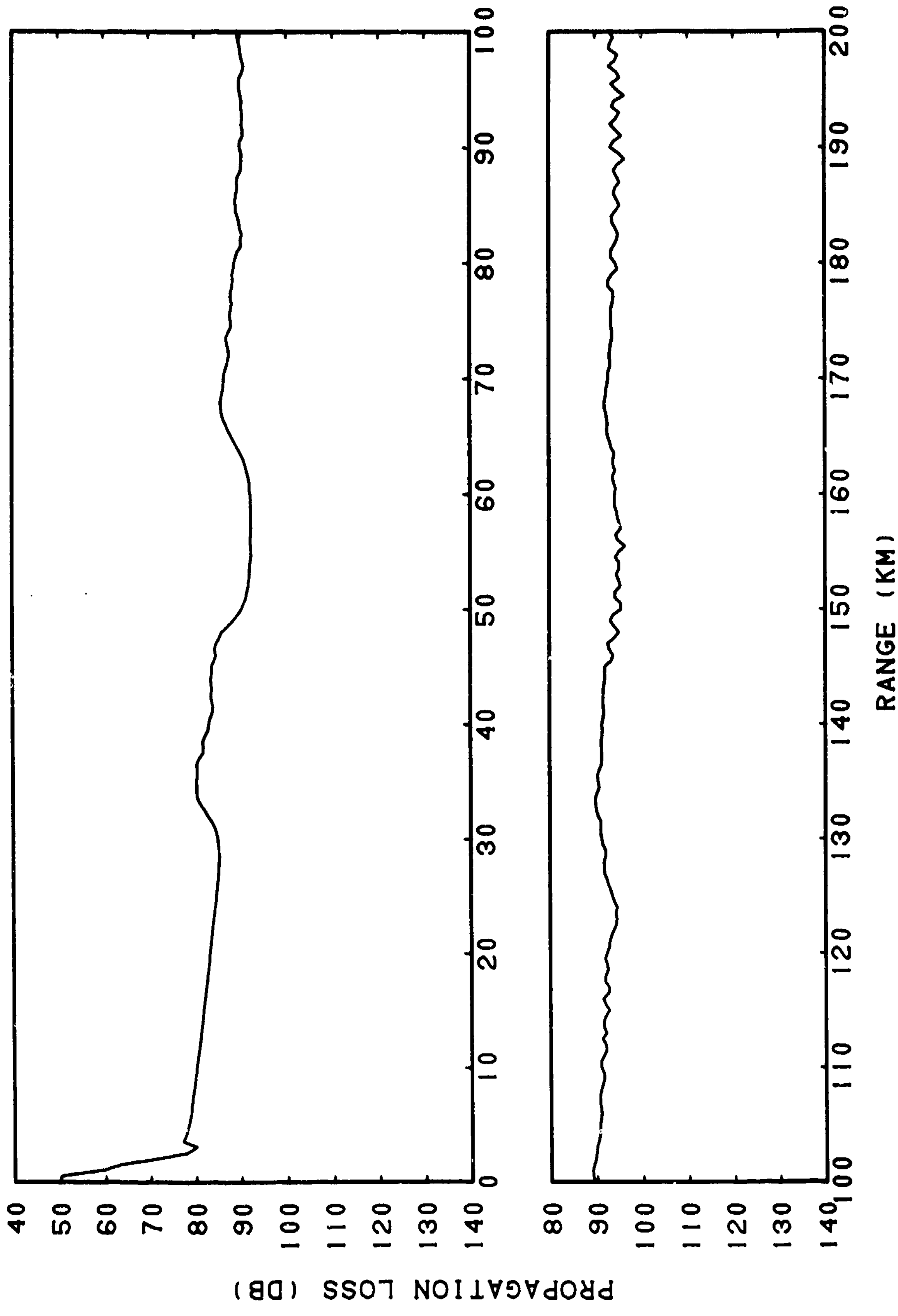
CONFIDENTIAL

(C) Figure IIIB-24. RAYMODE X (Coherent) Case IV, Bottom Loss = MGS Type 2, Frequency = 200 Hertz, Sliding Averages of 5 Points (2.00 Kilometers)



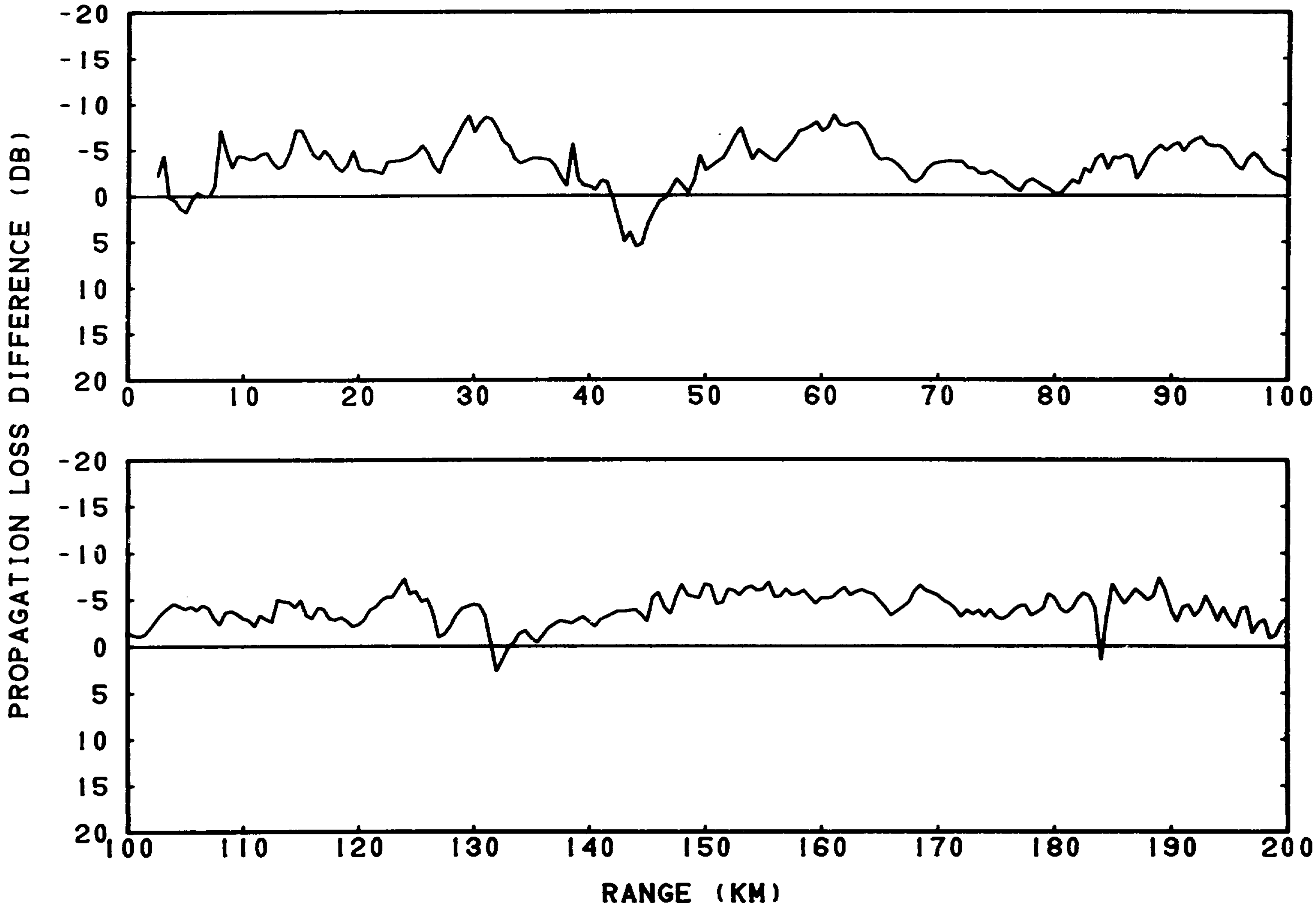
CONFIDENTIAL

(C) Figure IIIB-25. Smoothed RAYMODE X (Coherent) Case IV, Bottom Loss = MGS Type 2, Frequency = 200 Hertz, Subtracted from Hays-Murphy Experimental Data, Case IV, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 200 Hertz



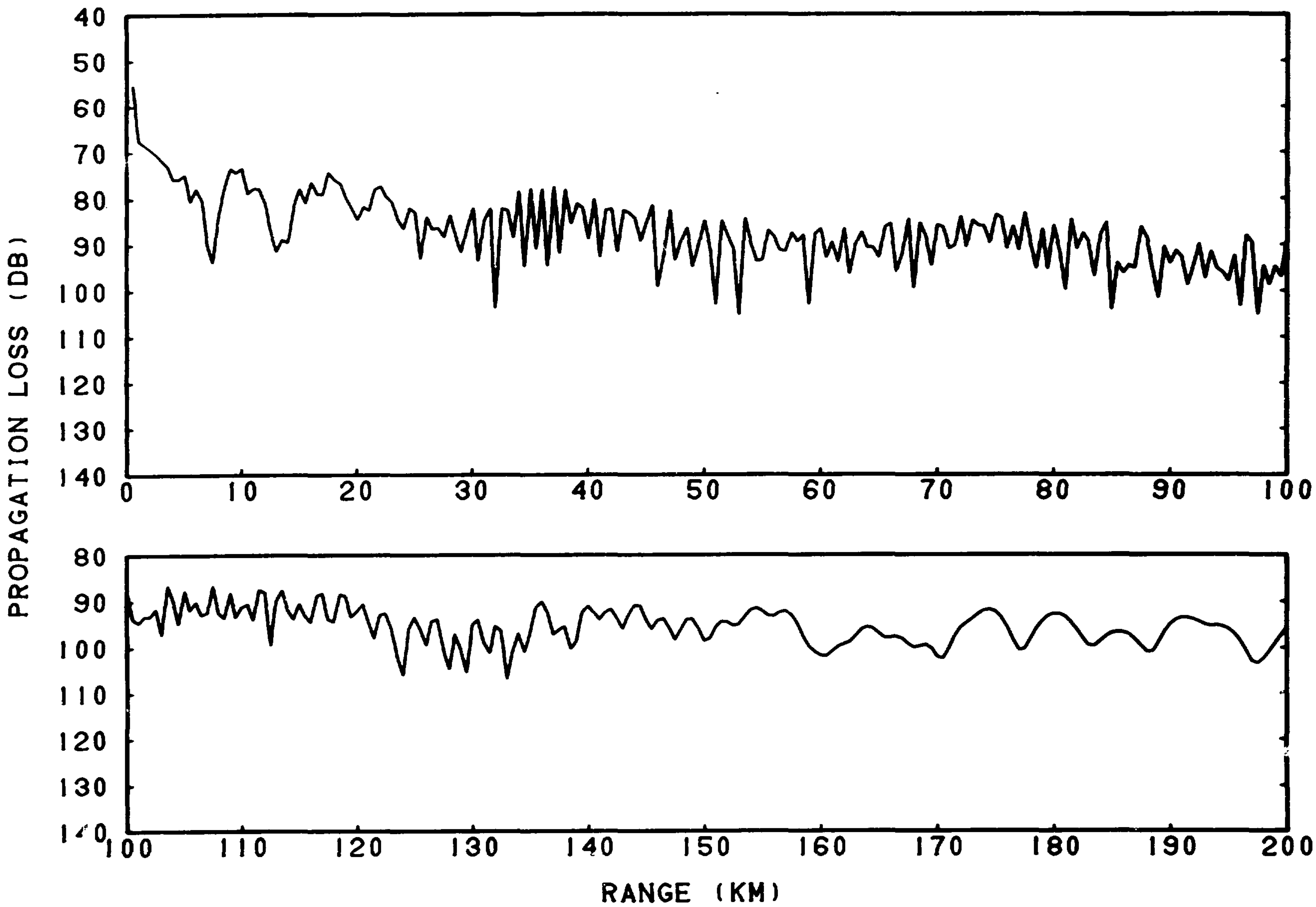
CONFIDENTIAL

(C) Figure IIIB-26. RAYMODE X (Incoherent) Case IV, Bottom Loss = MGS Type 2, Frequency = 200 Hertz



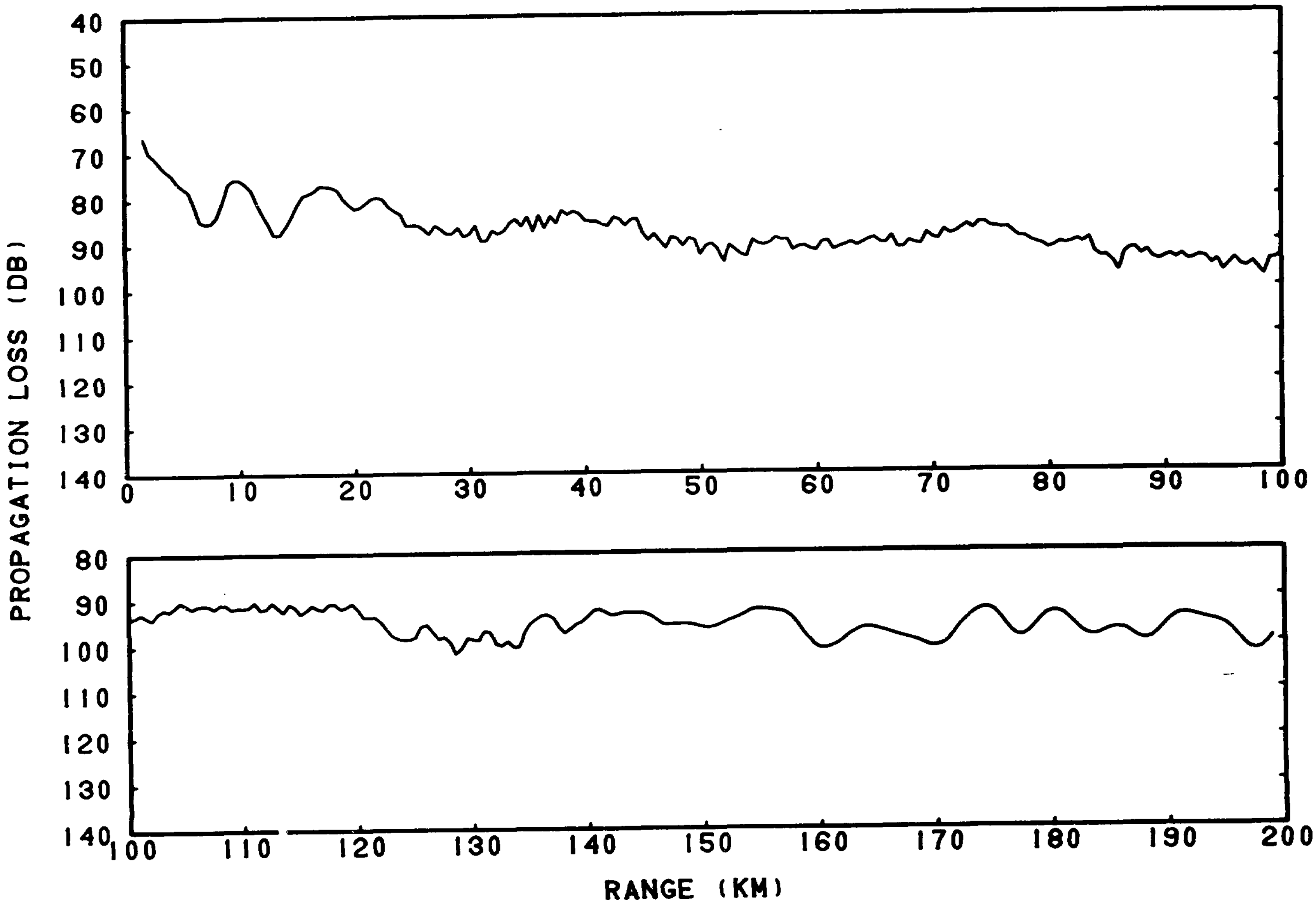
CONFIDENTIAL

(C) Figure IIIB-27. RAYMODE X (Incoherent) Case IV, Bottom Loss = MGS Type 2, Frequency = 200 Hertz, Subtracted from Hays-Murphy Experimental, Case IV, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 200 Hertz



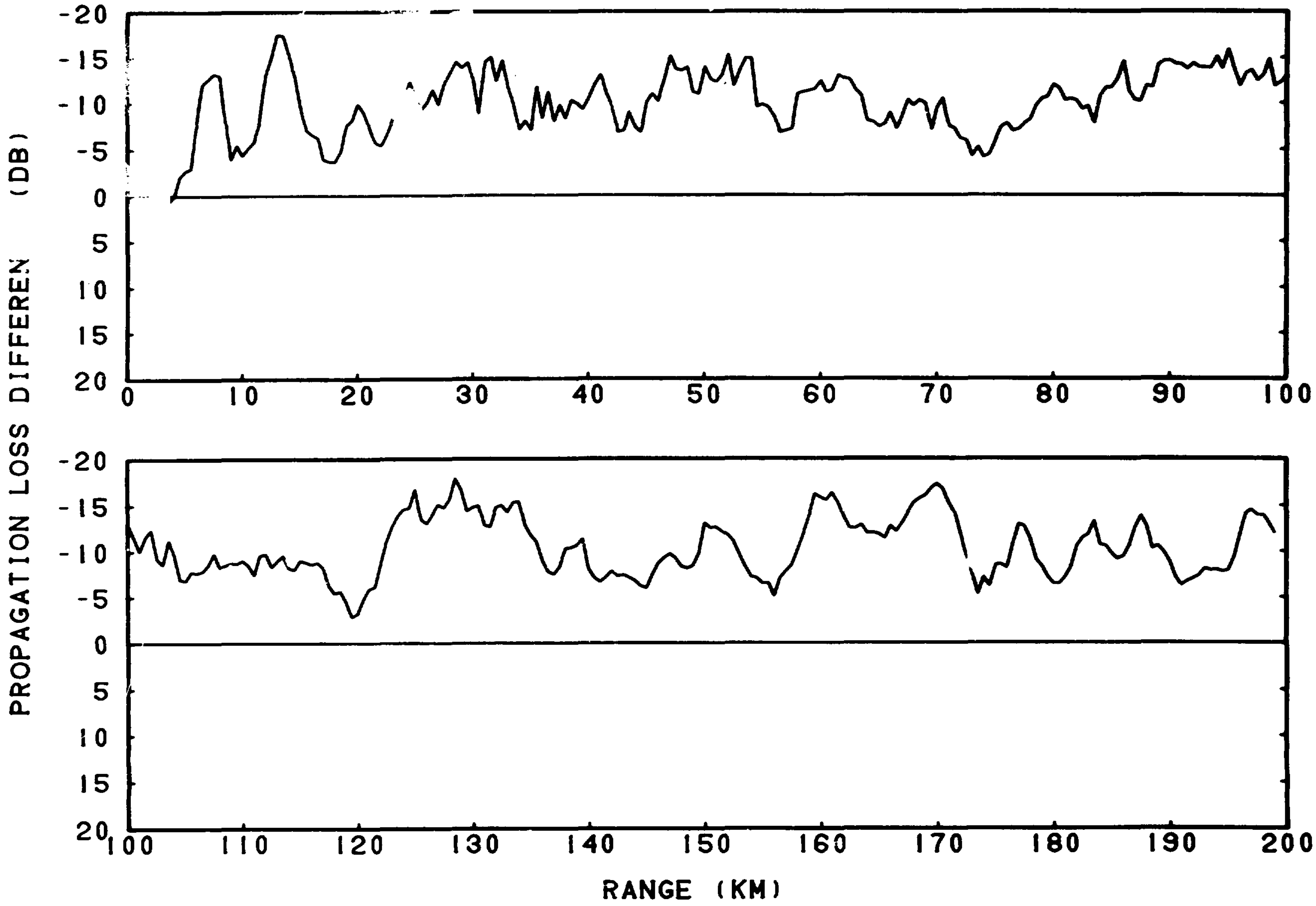
CONFIDENTIAL

(C) Figure IIIB-28. RAYMODE X (Coherent) Case V, Bottom Loss = MGS Type 2, Frequency = 35 Hertz



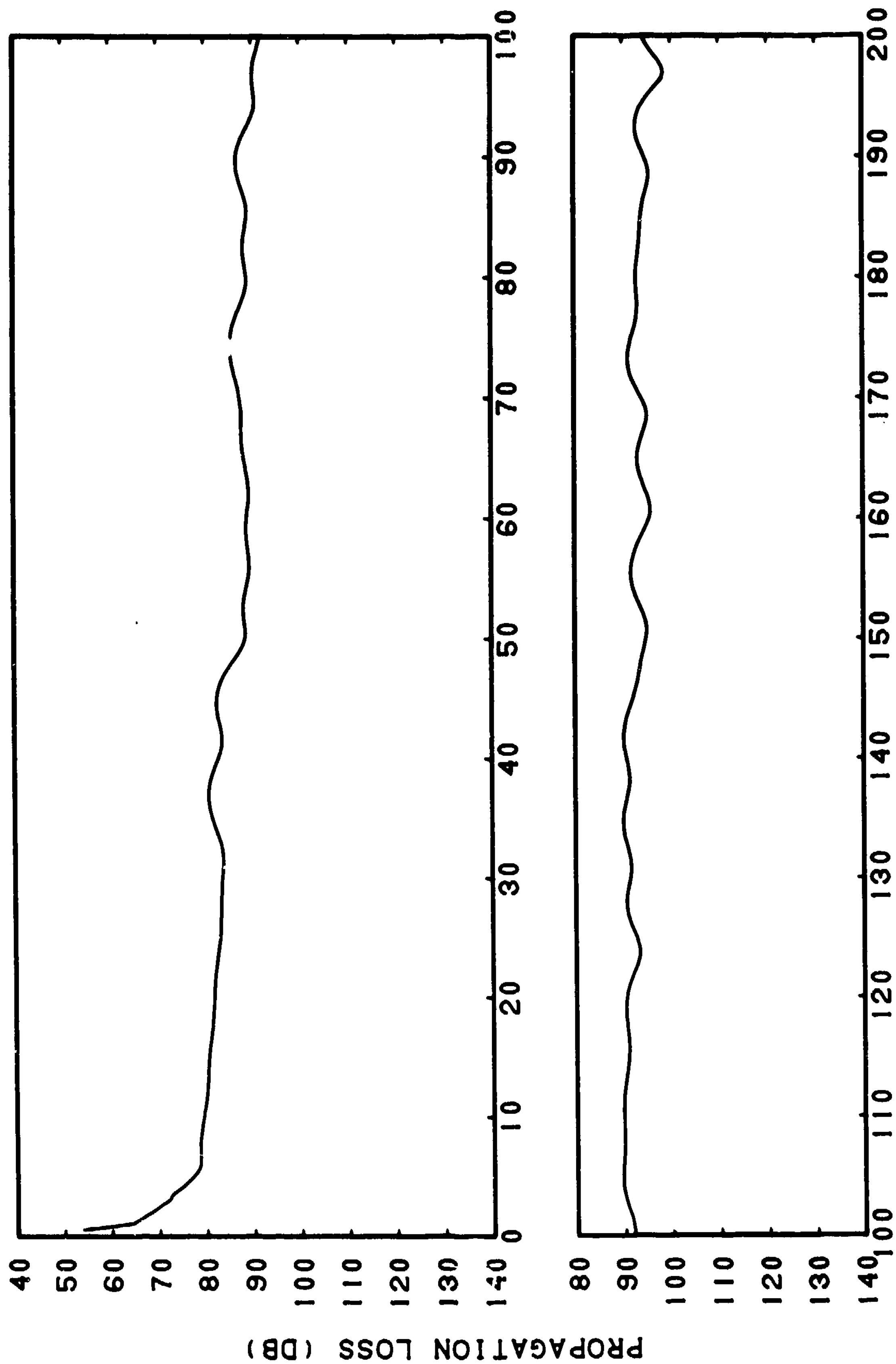
CONFIDENTIAL

(C) Figure IIIB-29. RAYMODE X (Coherent) Case V, Bottom Loss = MGS Type 2, Frequency = 35 Hertz, Sliding Averages of 5 Points (2.00 Kilometers)



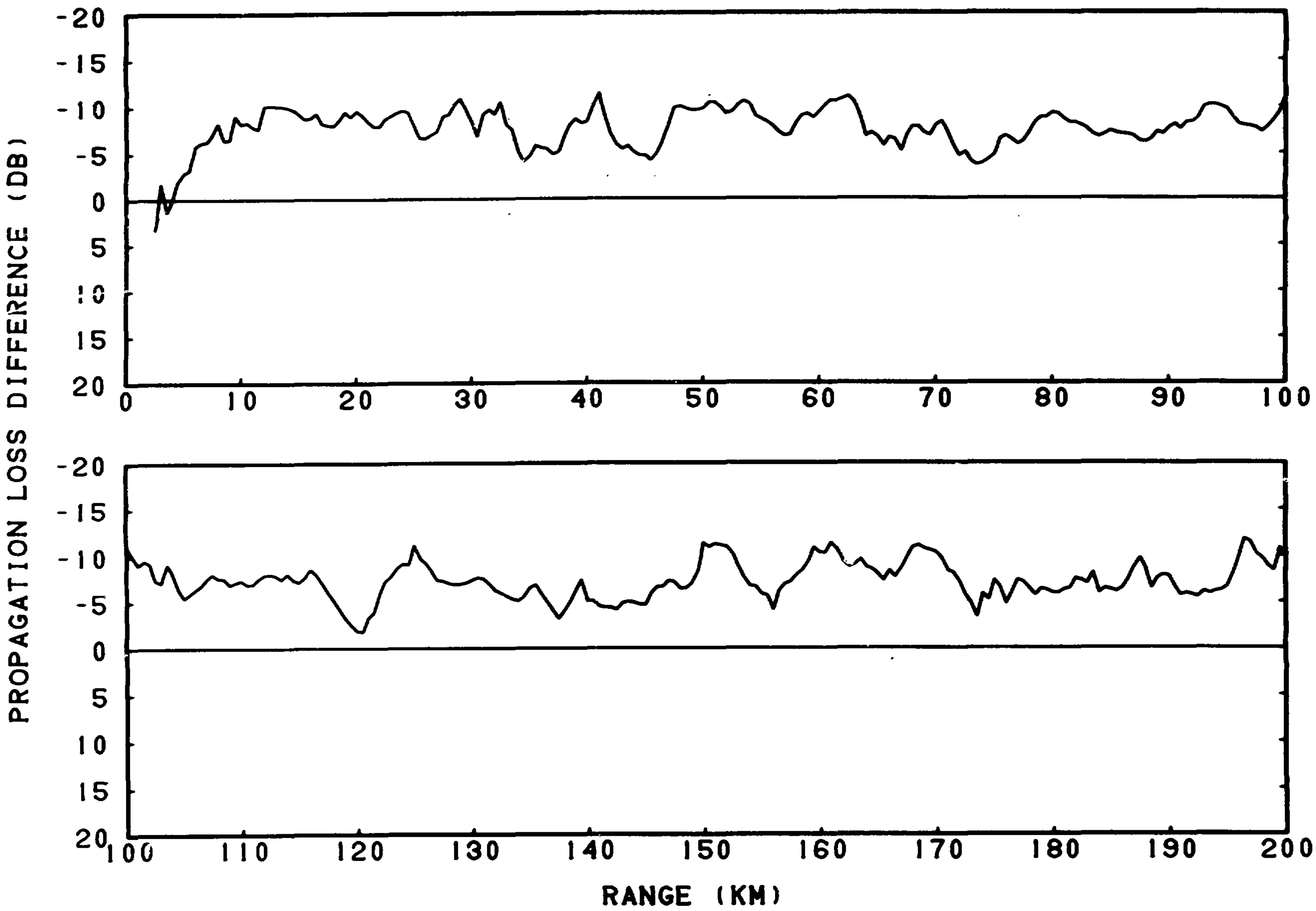
CONFIDENTIAL

(C) Figure IIIB-30. Smoothed RAYMODE X (Coherent) Case V, Bottom Loss = MGS Type 2, Frequency = 35 Hertz, Subtracted from Hays-Murphy Experimental Data, Case V, Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 35 Hertz



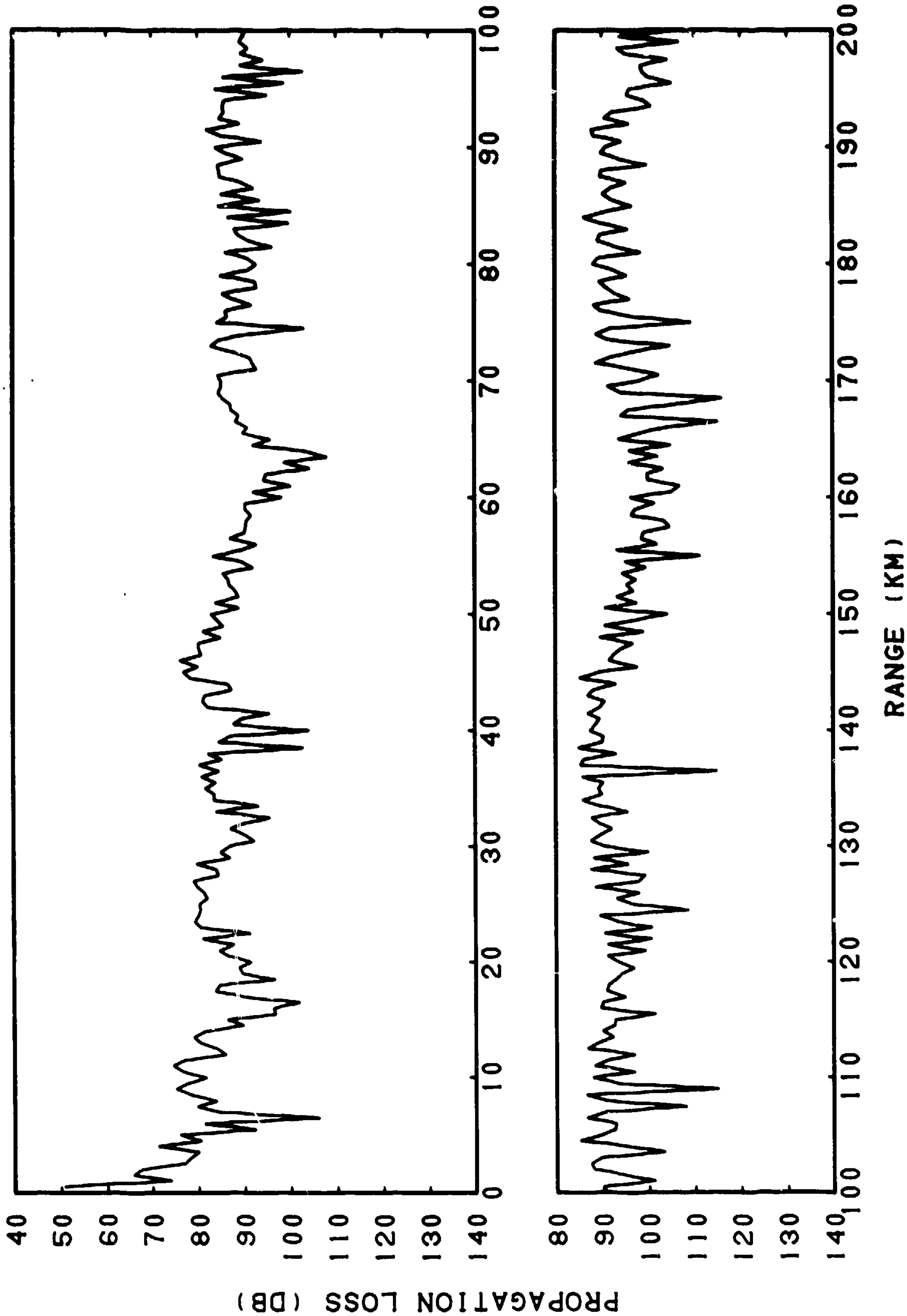
CONFIDENTIAL

(C) Figure IIIB-31. RAYMODE X (Incoherent) Case V, Bottom Loss = MGS Type 2, Frequency = 35 Hertz



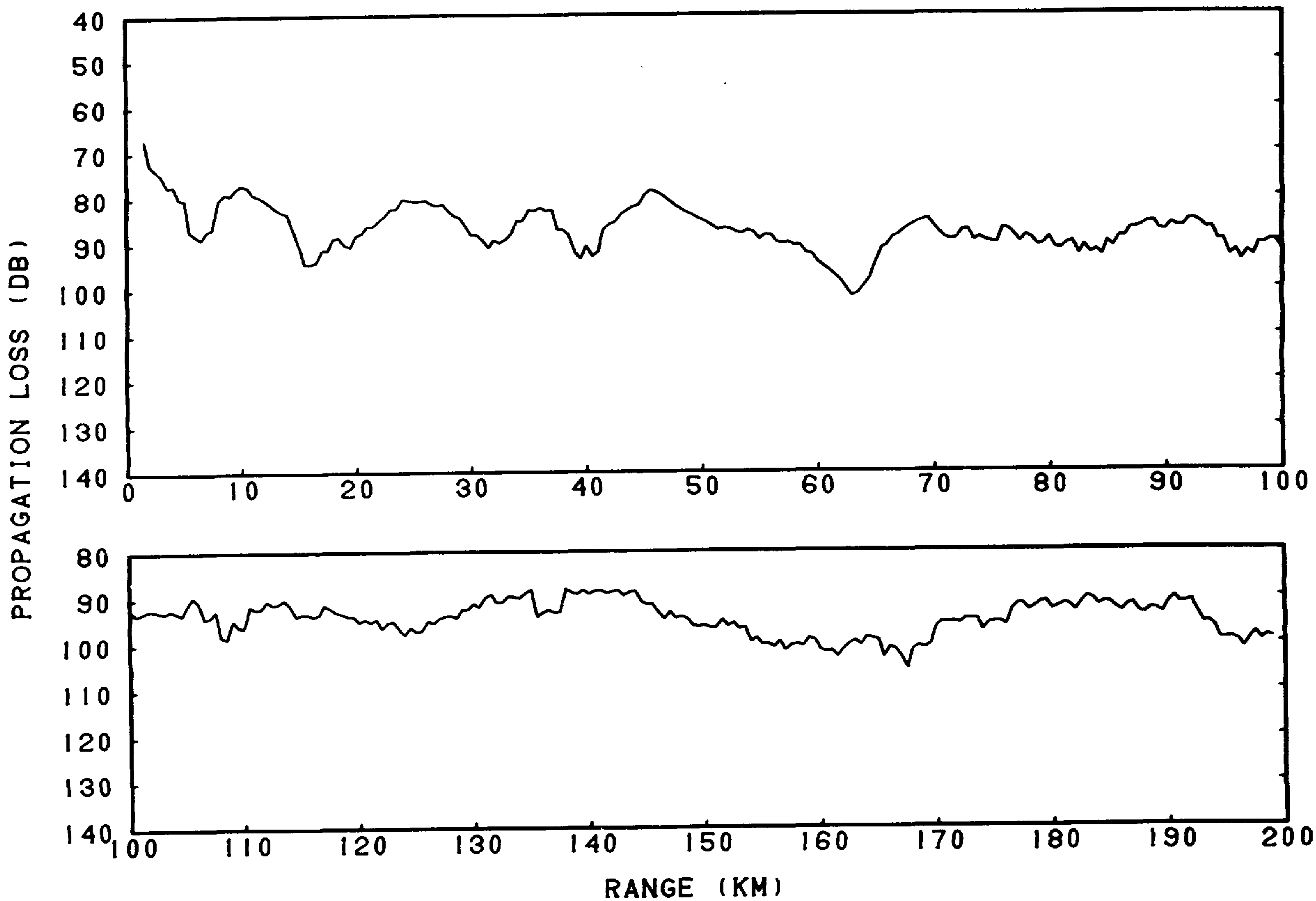
CONFIDENTIAL

(C) Figure IIIB-32. RAYMODE X (Incoherent) Case V, Bottom Loss = MGS Type 2, Frequency = 35 Hertz, Subtracted from Hays-Murphy Experimental Data, Case V, Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 35 Hertz



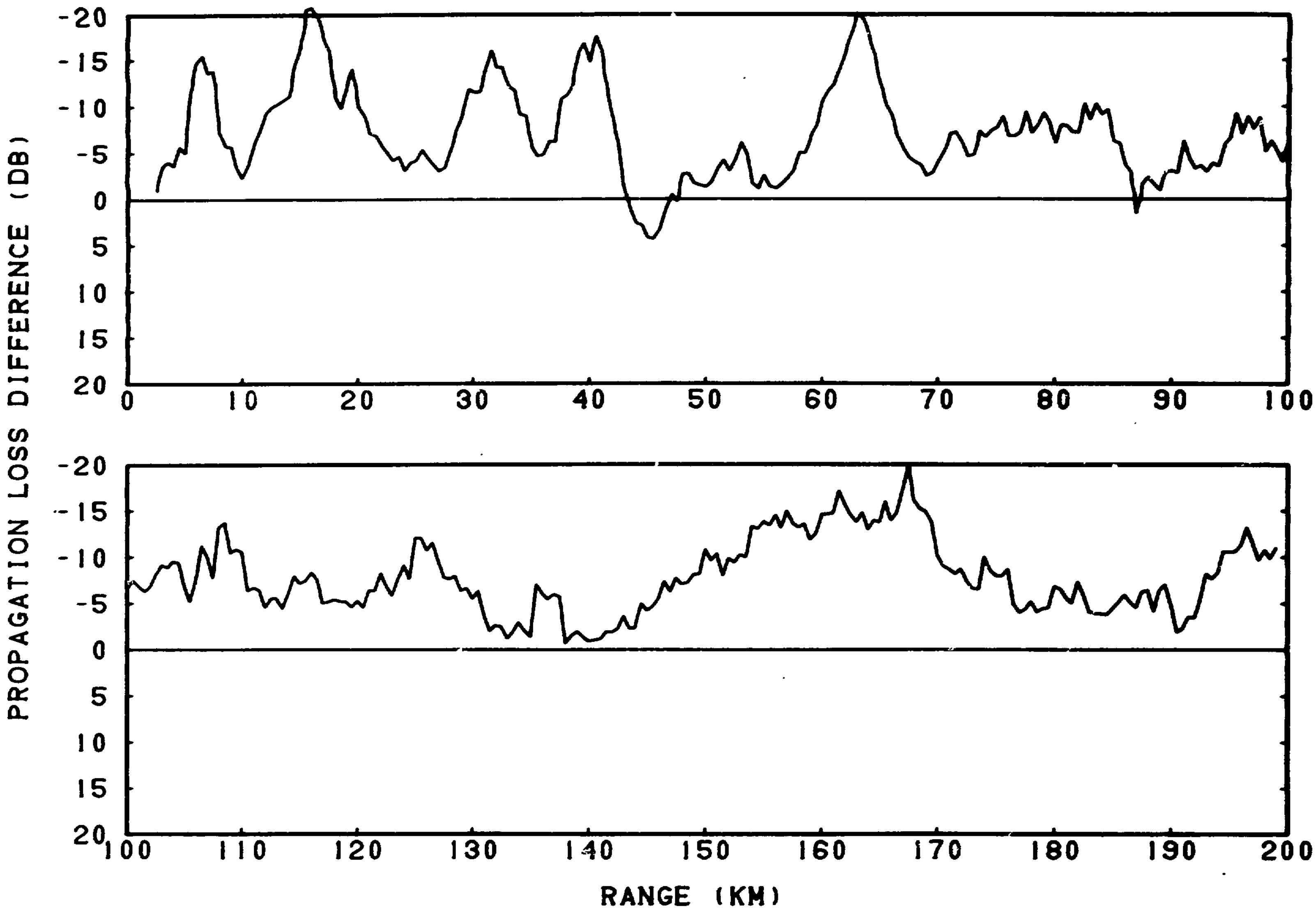
CONFIDENTIAL

(C) Figure IIIB-33. RAYMODE X (Coherent) Case VI, Bottom Loss = MGS Type 2, Frequency = 100 Hertz



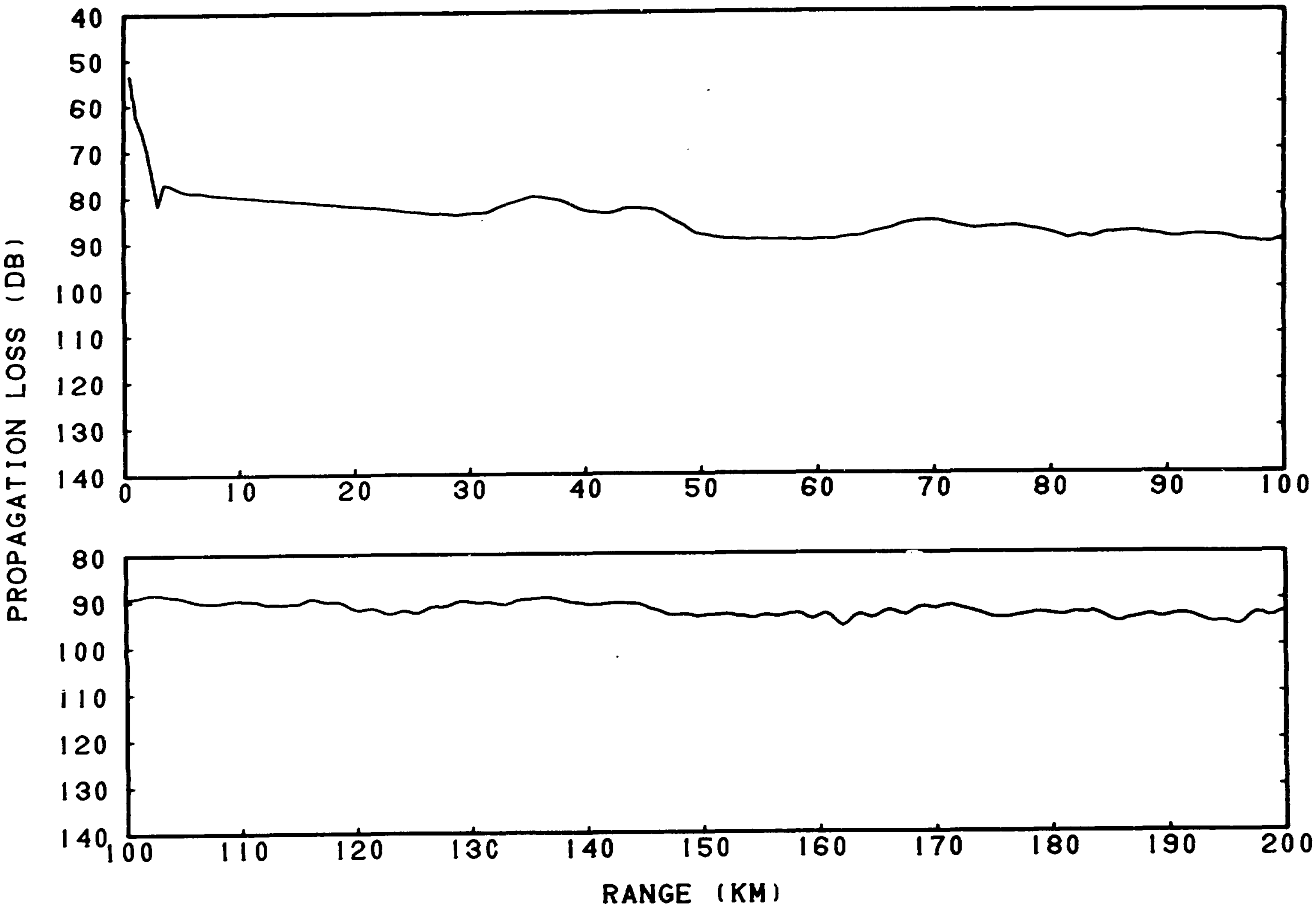
CONFIDENTIAL

(C) Figure IIIB-34. RAYMODE X (Coherent) Case VI, Bottom Loss = MGS Type 2, Frequency = 100 Hertz, Sliding Averages of 5 Points (2.00 Kilometers)



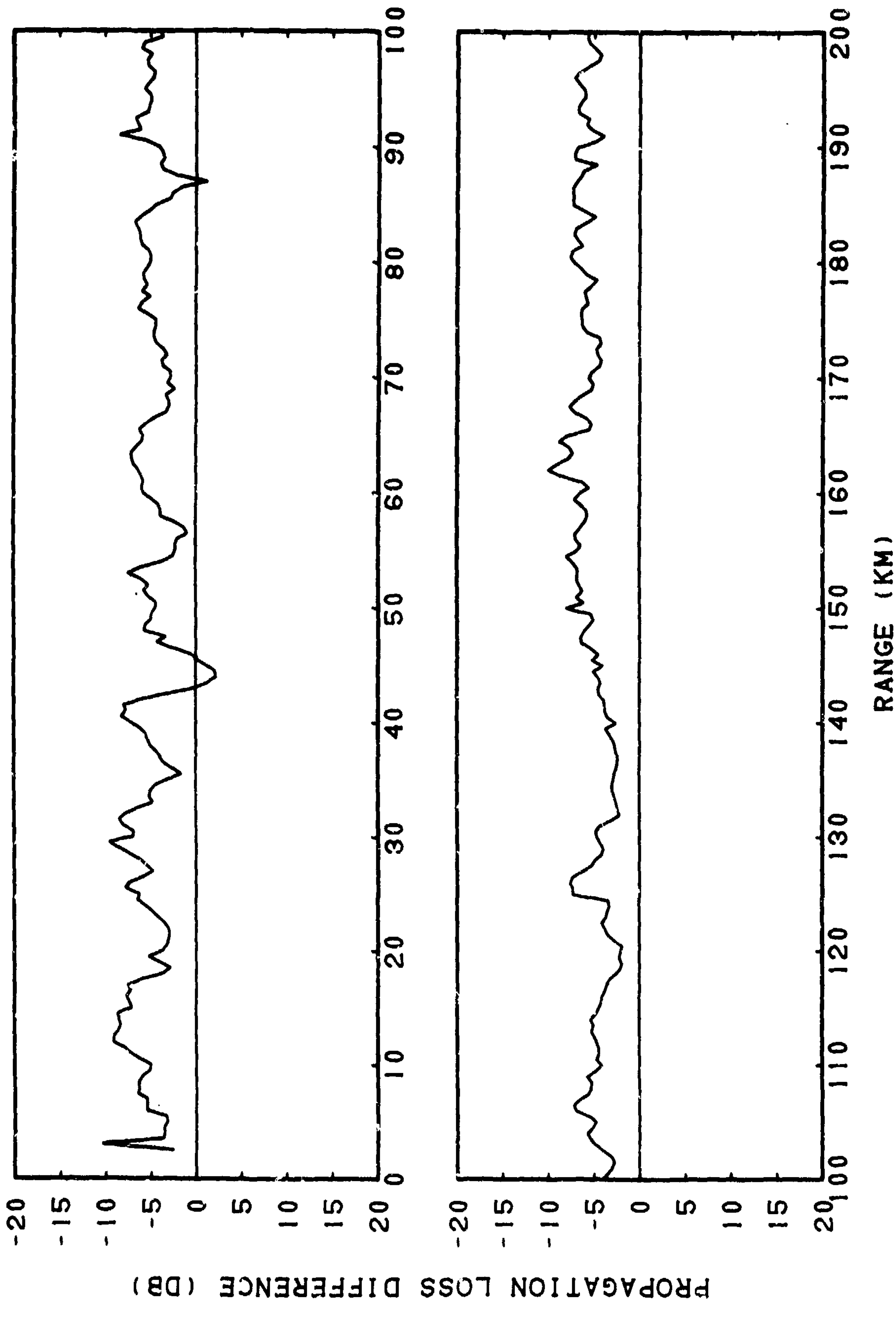
CONFIDENTIAL

(C) Figure IIIB-35. Smoothed RAYMODE X (Coherent) Case VI, Bottom Loss = MGS Type 2, Frequency = 100 Hertz, Subtracted from Hays-Murphy Experimental Data, Case VI, Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 100 Hertz



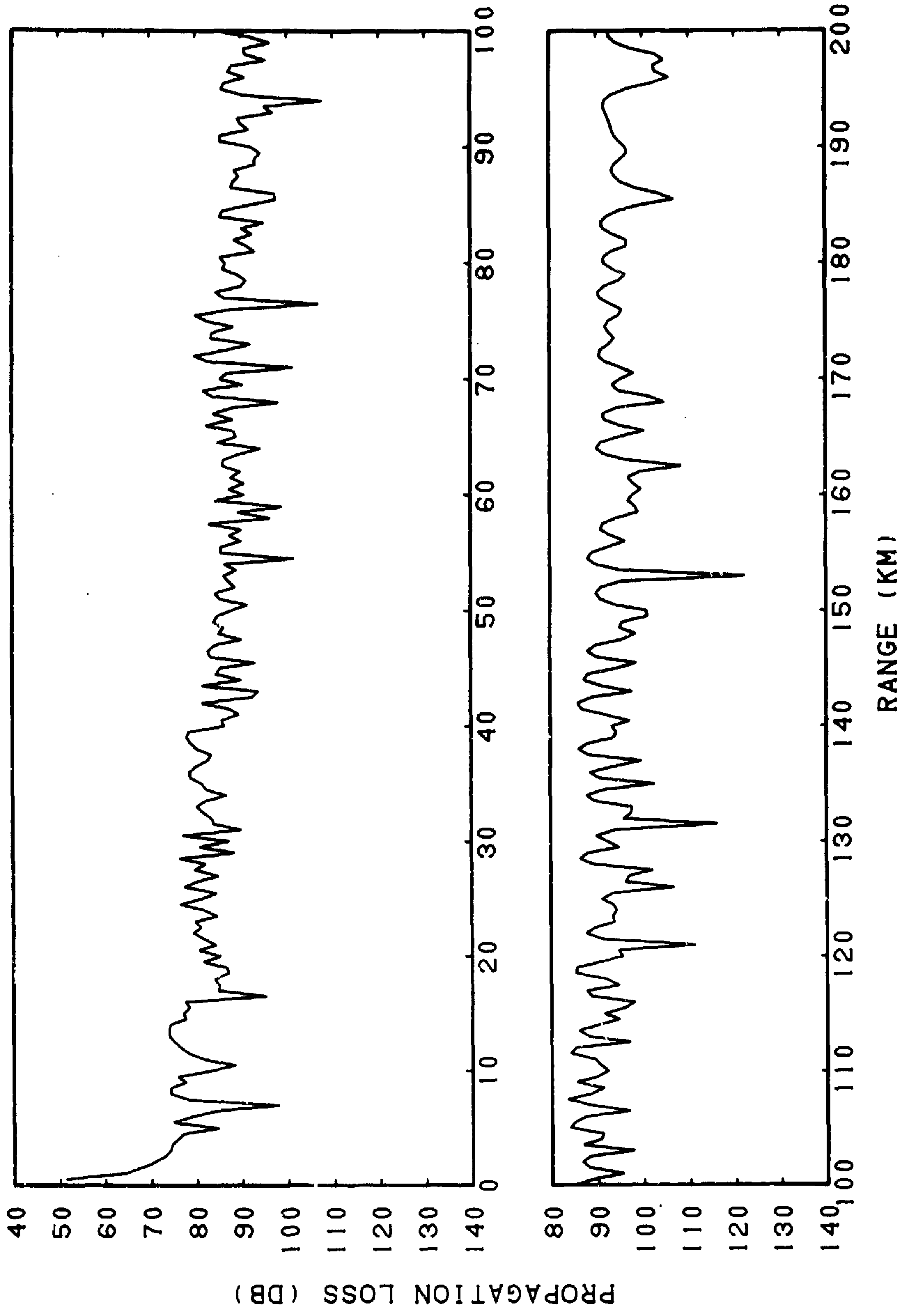
CONFIDENTIAL

(C) Figure IIIB-36. RAYMODE X (Incoherent) Case VI, Bottom Loss = MGS Type 2, Frequency = 100 Hertz



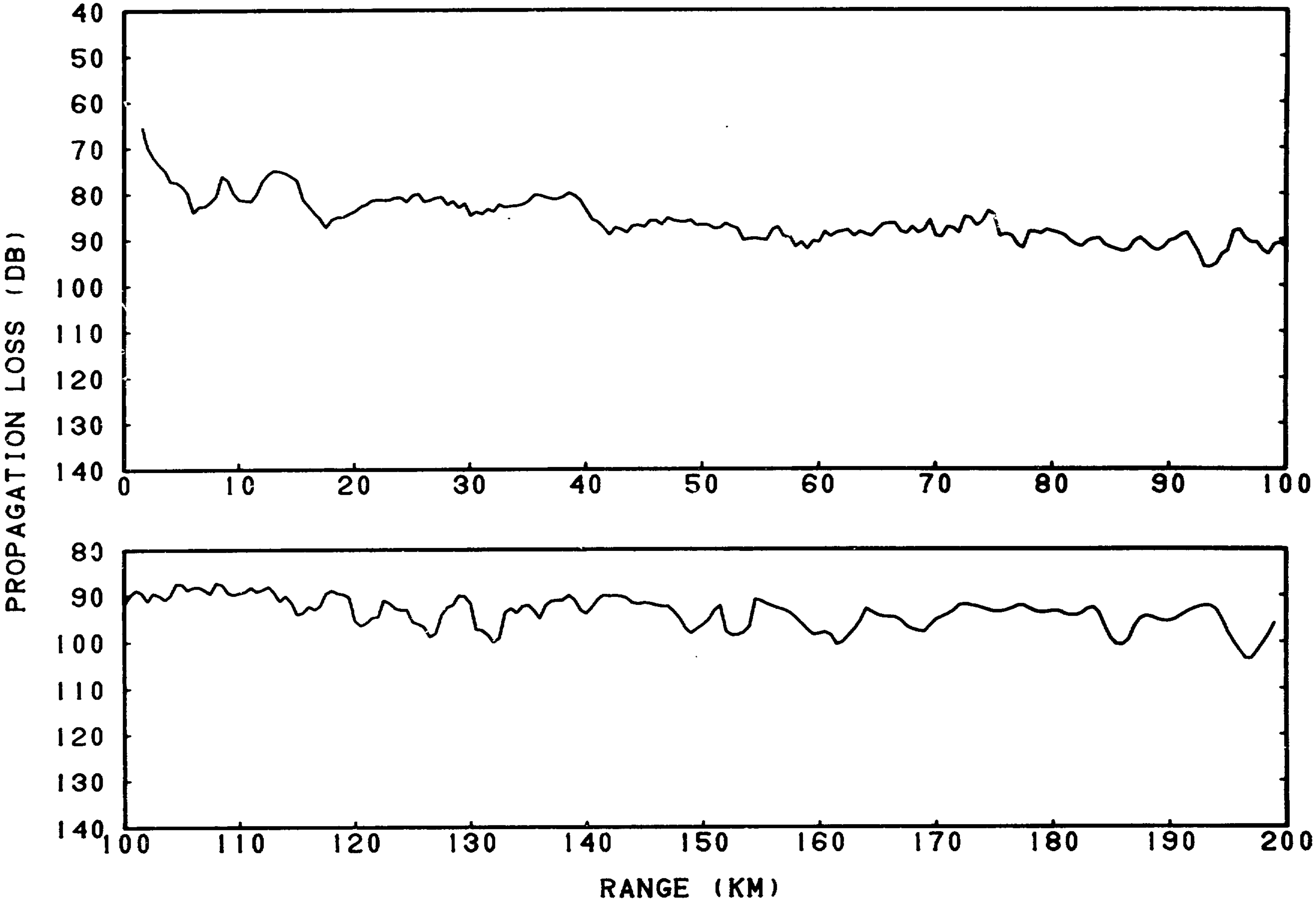
CONFIDENTIAL

(C) Figure IIIB-37. RAYMODE X (Incoherent) Case VI, Bottom Loss = MGS Type 2, Frequency = 100 Hertz, Subtracted from Hays-Murphy Experimental Data, Case VI, Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 100 Hertz



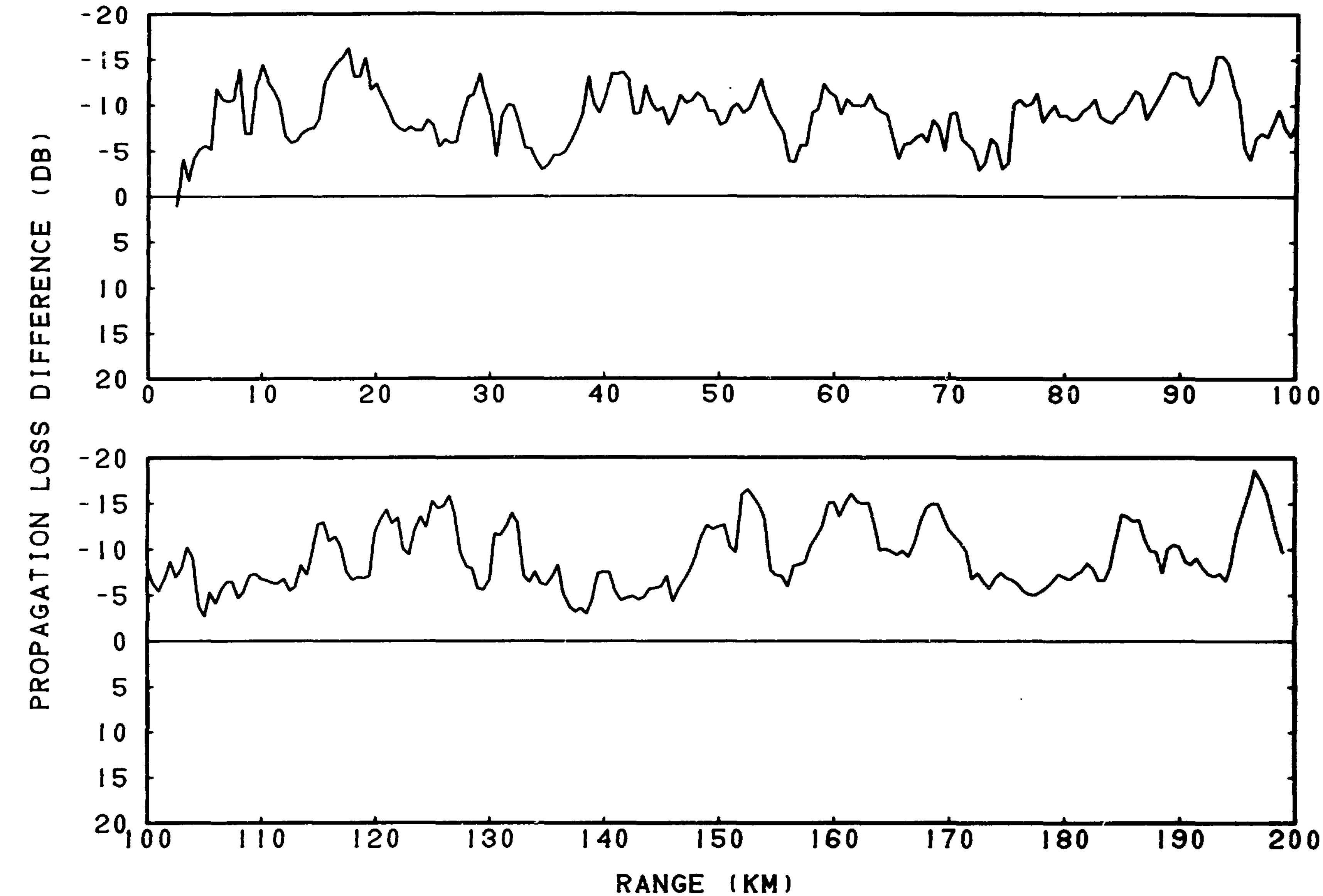
CONFIDENTIAL

(C) Figure IIIB-38. RAYMODE X (Coherent) Case I, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz



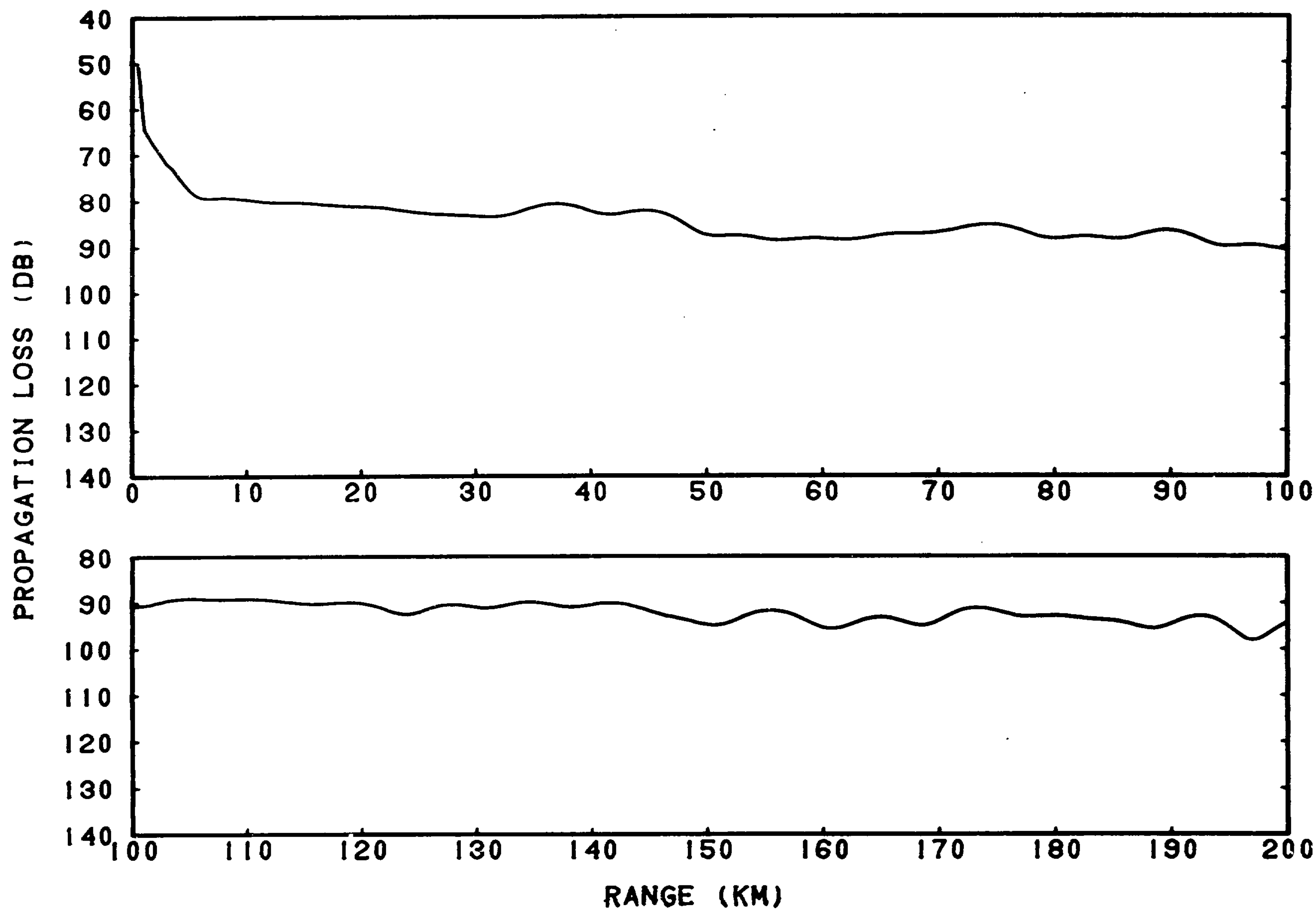
CONFIDENTIAL

(C) Figure IIIB-39. RAYMODE X (Coherent) Case I, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz, Sliding Averages of 5 Points (2.00 Kilometers)



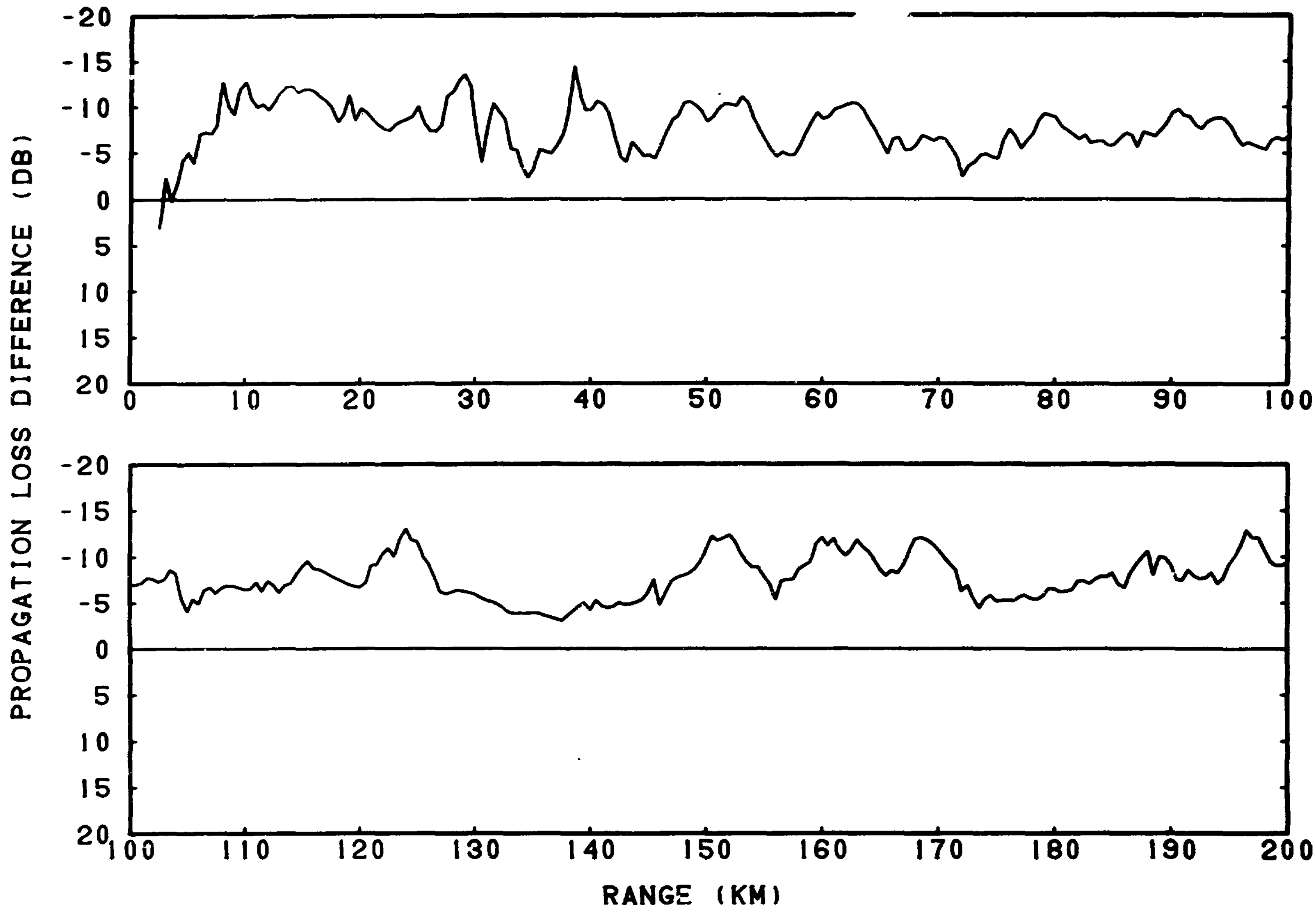
CONFIDENTIAL

(C) Figure IIIB-40. Smoothed RAYMODE X (Coherent) Case I, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz, Subtracted from Hays-Murphy Experimental Data, Case I, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 35 Hertz



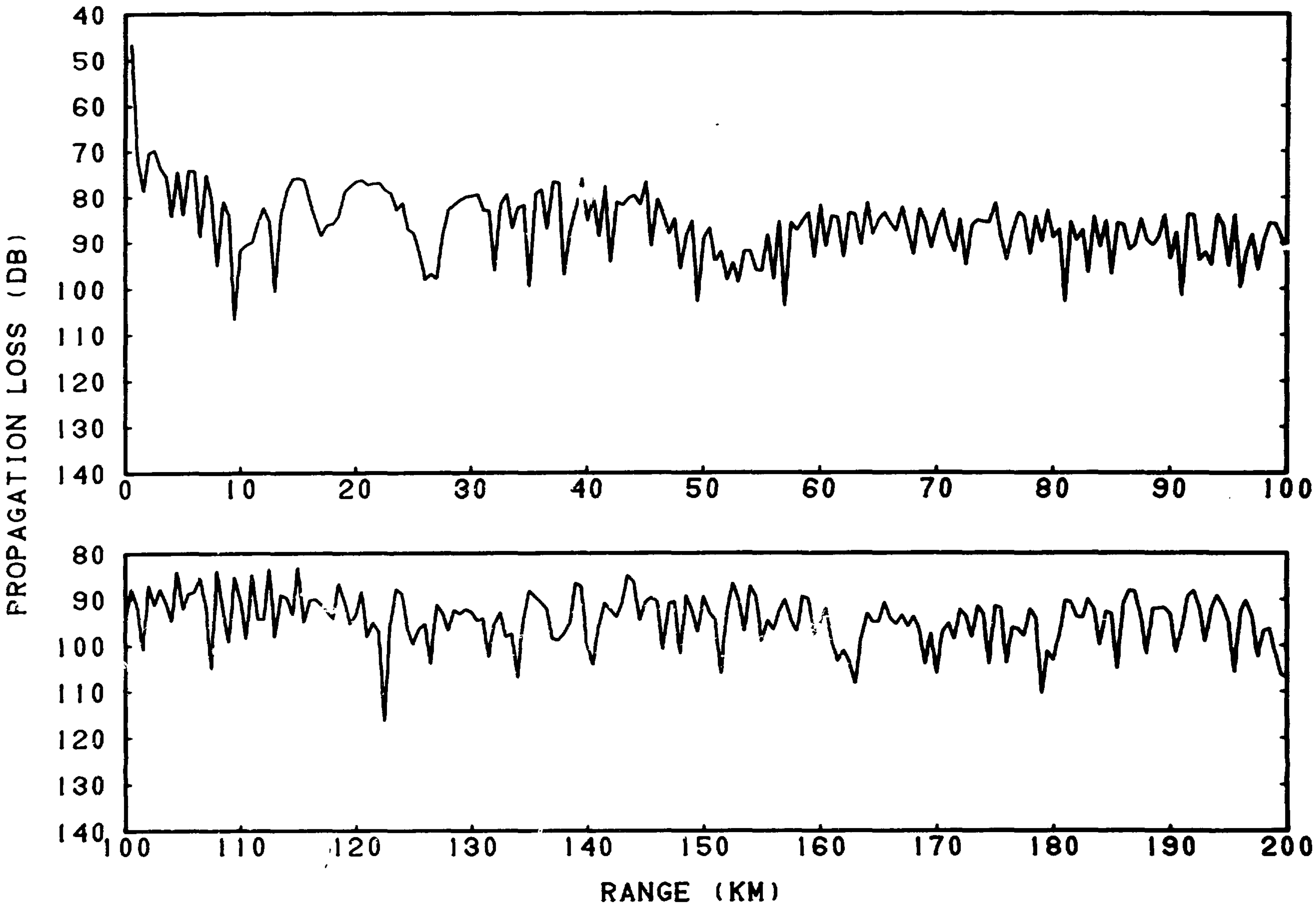
CONFIDENTIAL

(C) Figure IIIB-41. RAYMODE X (Incoherent) Case I, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz



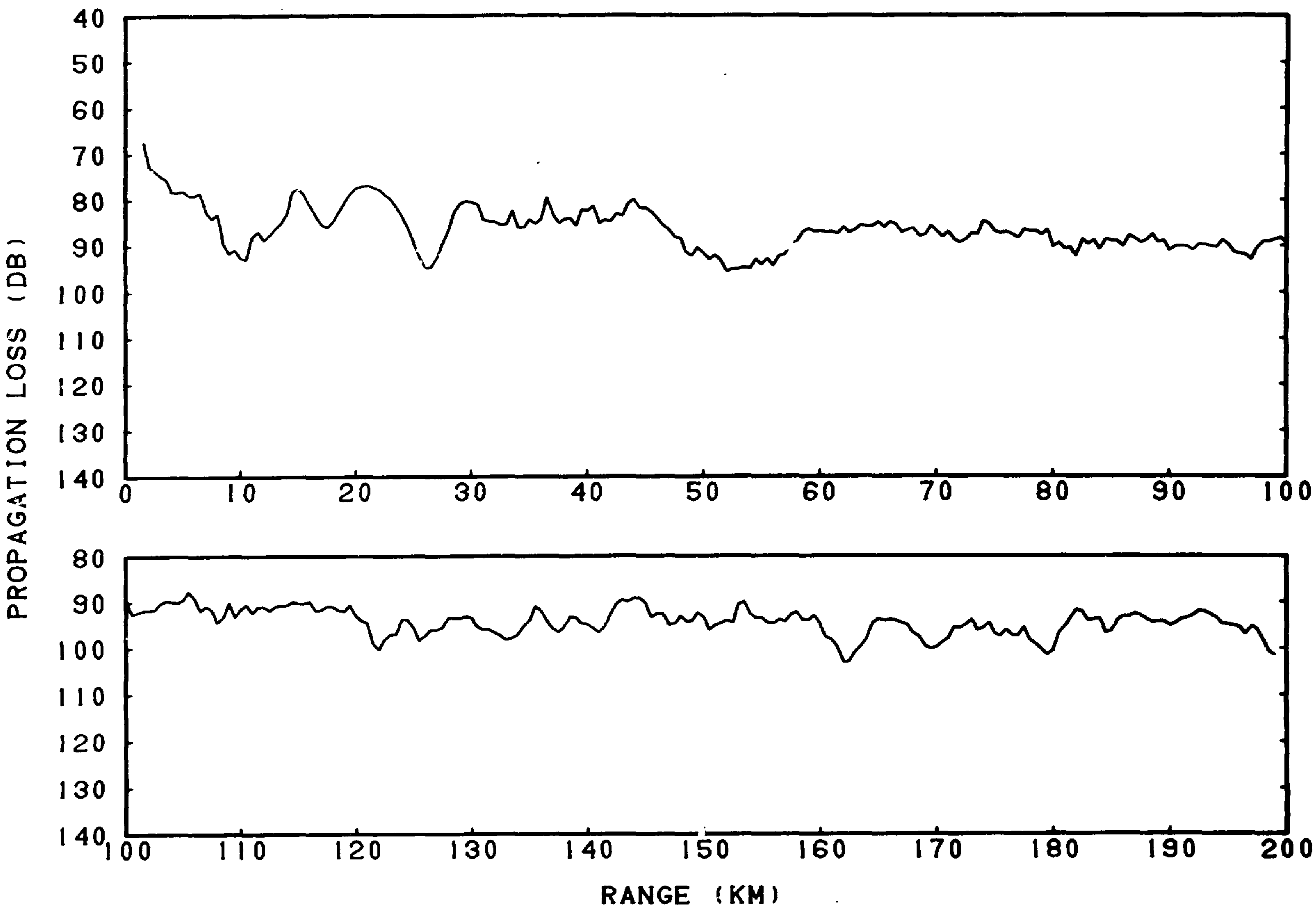
CONFIDENTIAL

(C) Figure IIIB-42. RAYMODE X (Incoherent) Case I, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz, Subtracted from Hays-Murphy Experimental Data, Case I, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 35 Hertz



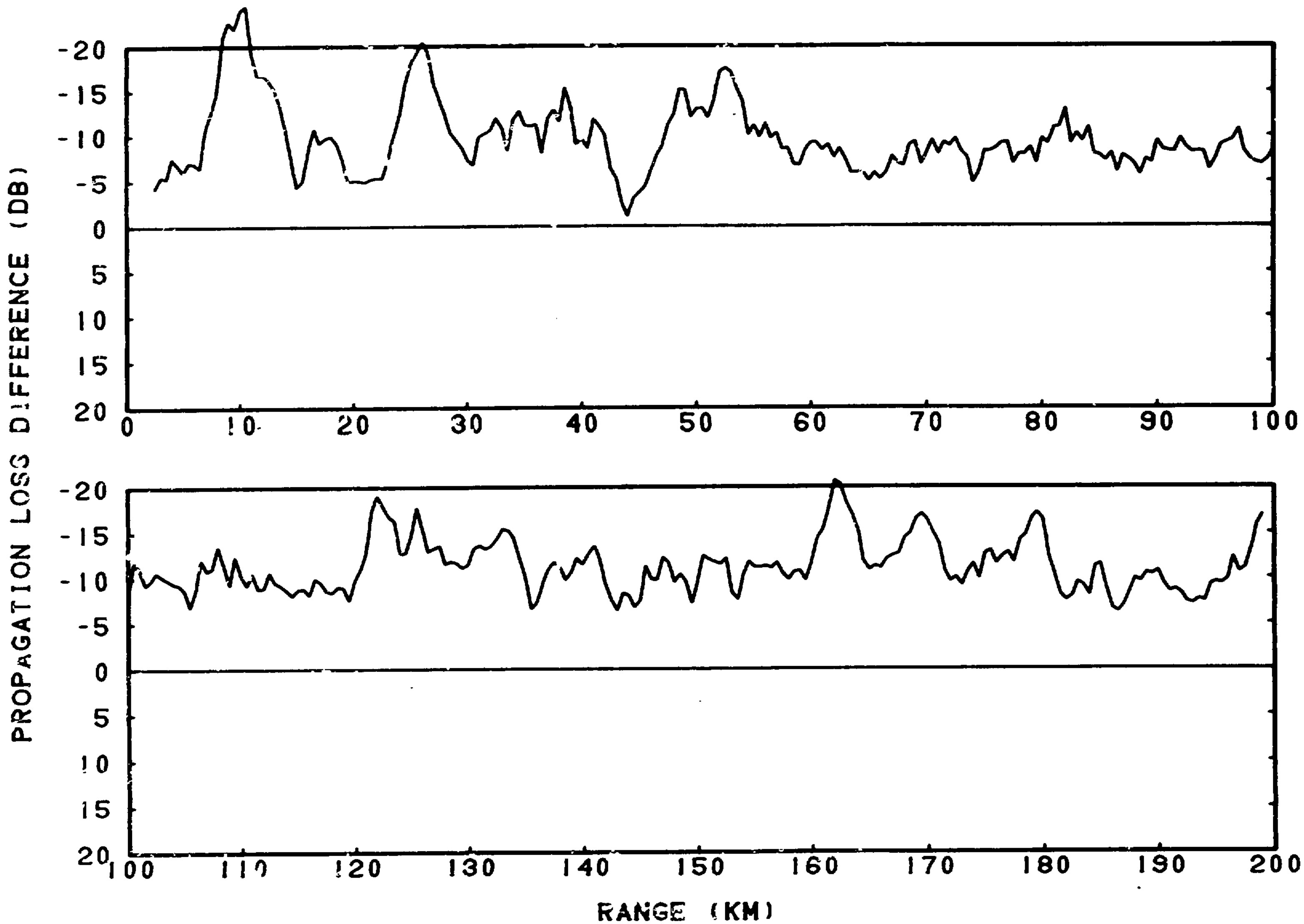
CONFIDENTIAL

(C) Figure IIIB-43. RAYMODE X (Coherent) Case II, Bottom Loss = FNOC Type 3, Frequency = 67.5 Hertz



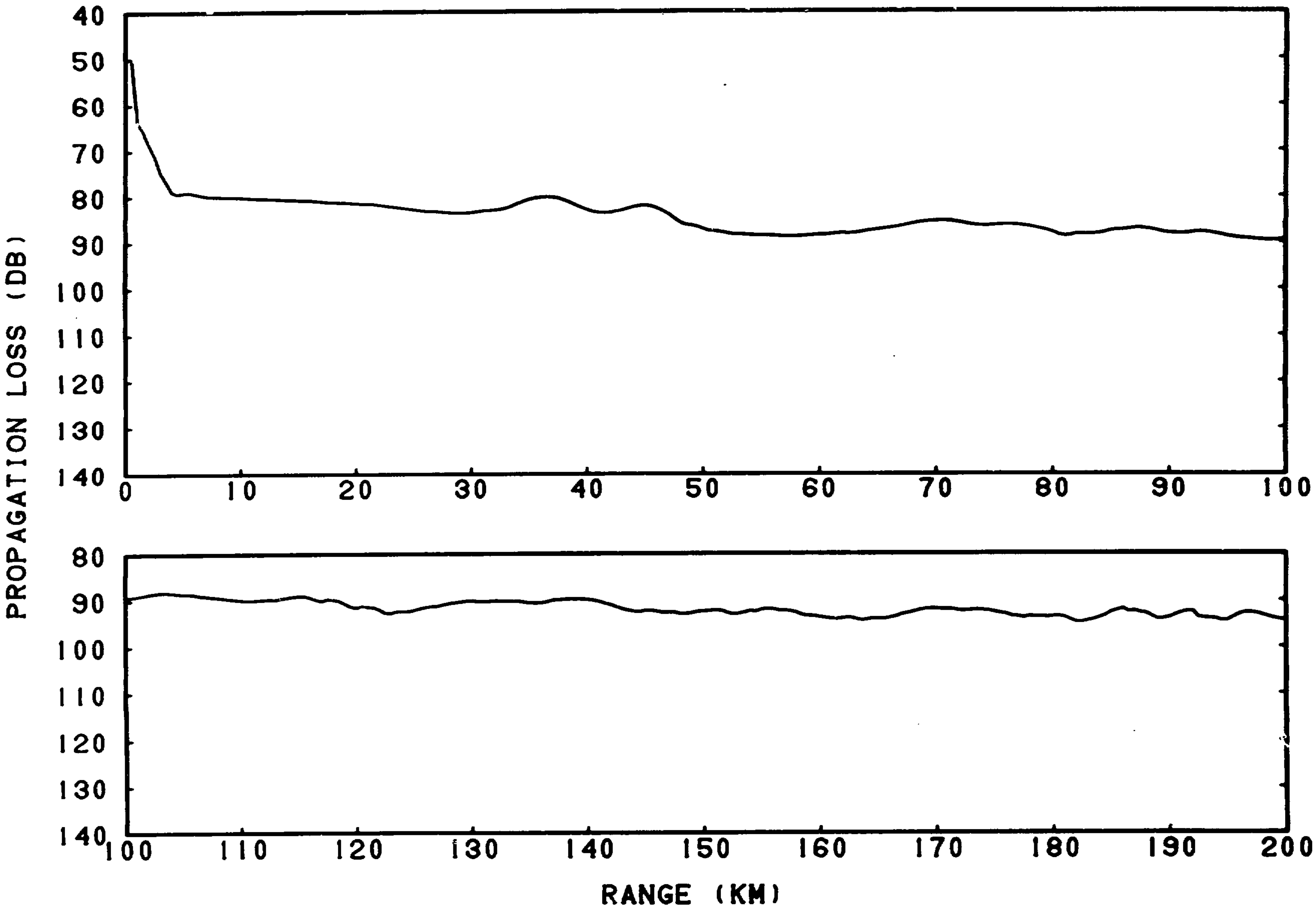
CONFIDENTIAL

(C) Figure IIIB-44. RAYMODE X (Coherent) Case II, Bottom Loss = FNOC Type 3, Frequency = 67.5 Hertz, Sliding Averages of 5 Points (2.00 Kilometers)



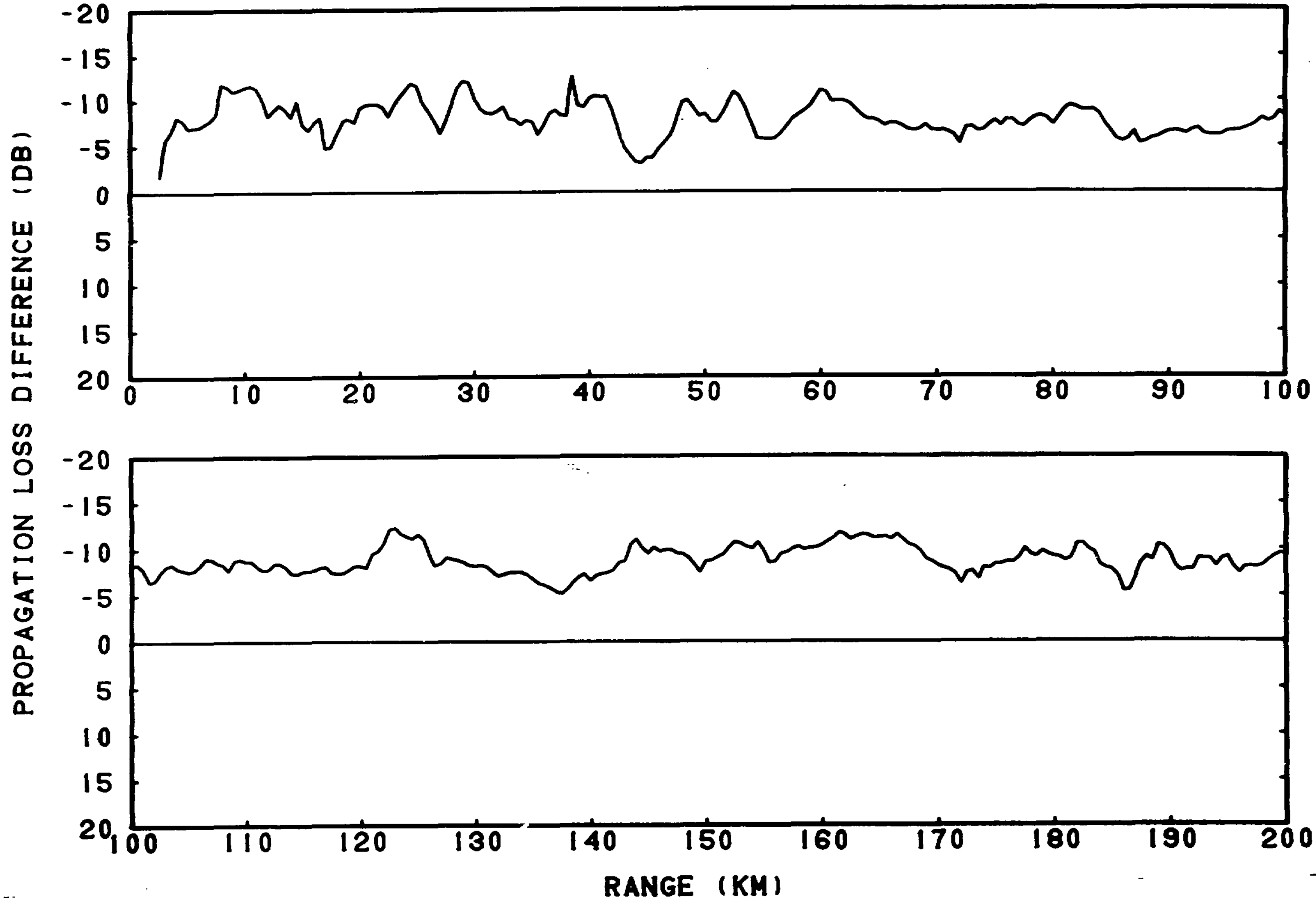
CONFIDENTIAL

(C) Figure IIIB-45. Smoothed RAYMODE X (Coherent) Case II, Bottom Loss = FNOC Type 3, Frequency = 67.5 Hertz, Subtracted from Hays-Murphy Experimental Data, Case II, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 67.5 Hertz



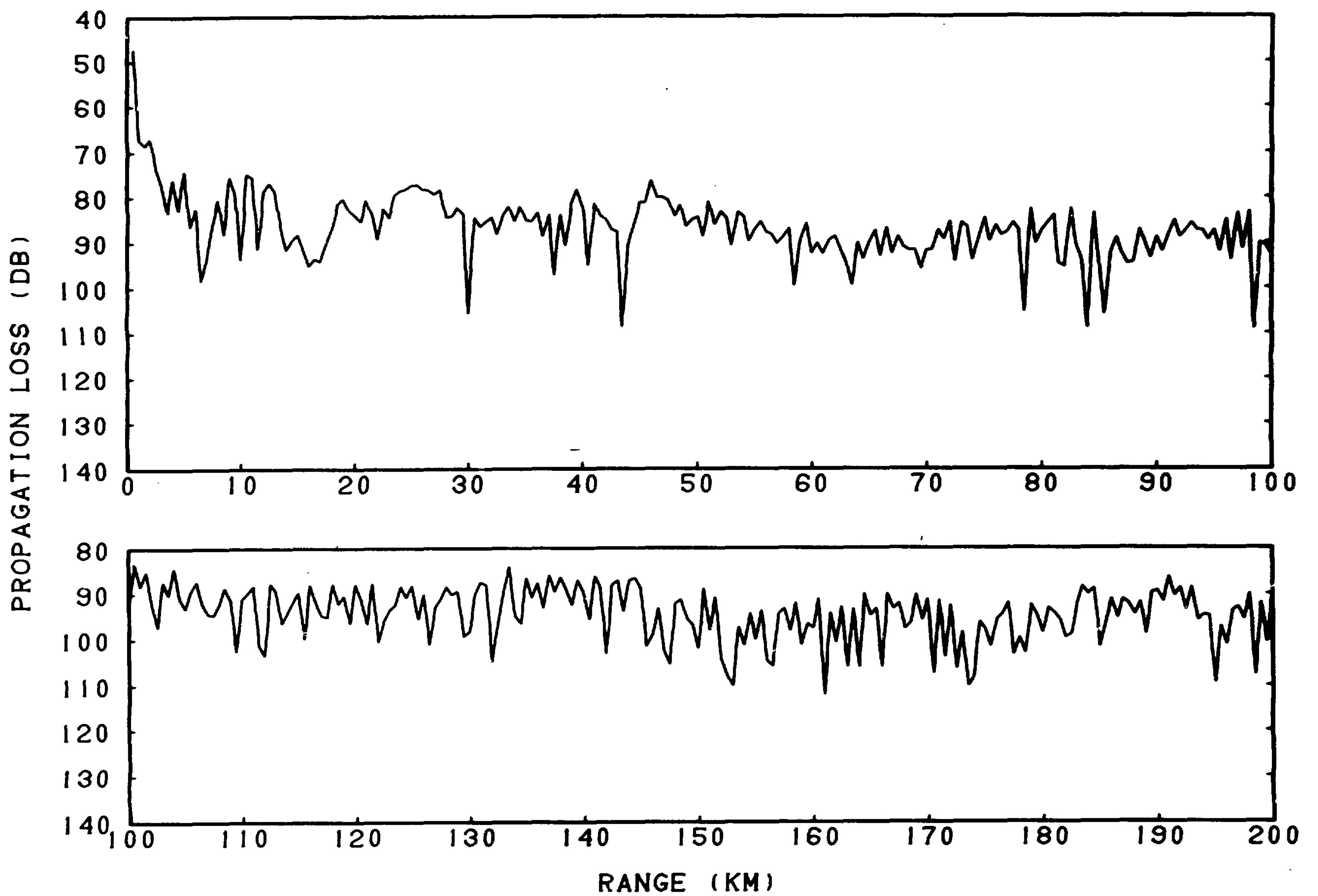
CONFIDENTIAL

(C) Figure IIIB-46. RAYMODE X (Incoherent) Case II, Bottom Loss = FNOC Type 3, Frequency = 67.5 Hertz



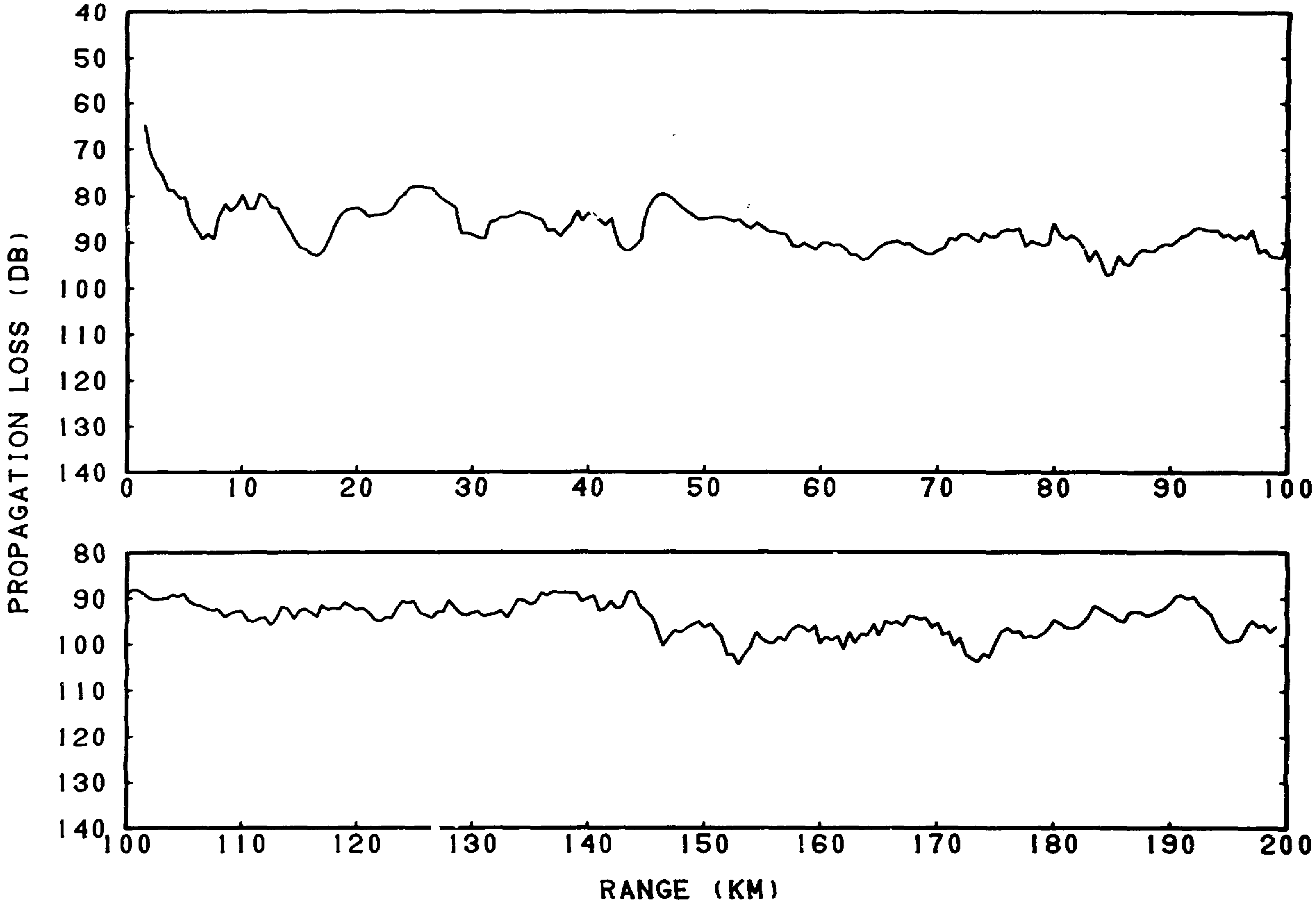
CONFIDENTIAL

(C) Figure IIIB-47. RAYMODE X (Incoherent) Case II, Bottom Loss = FNOC Type 3, Frequency = 67.5 Hertz, Subtracted from Hays-Murphy Experimental Data, Case II, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 67.5 Hertz



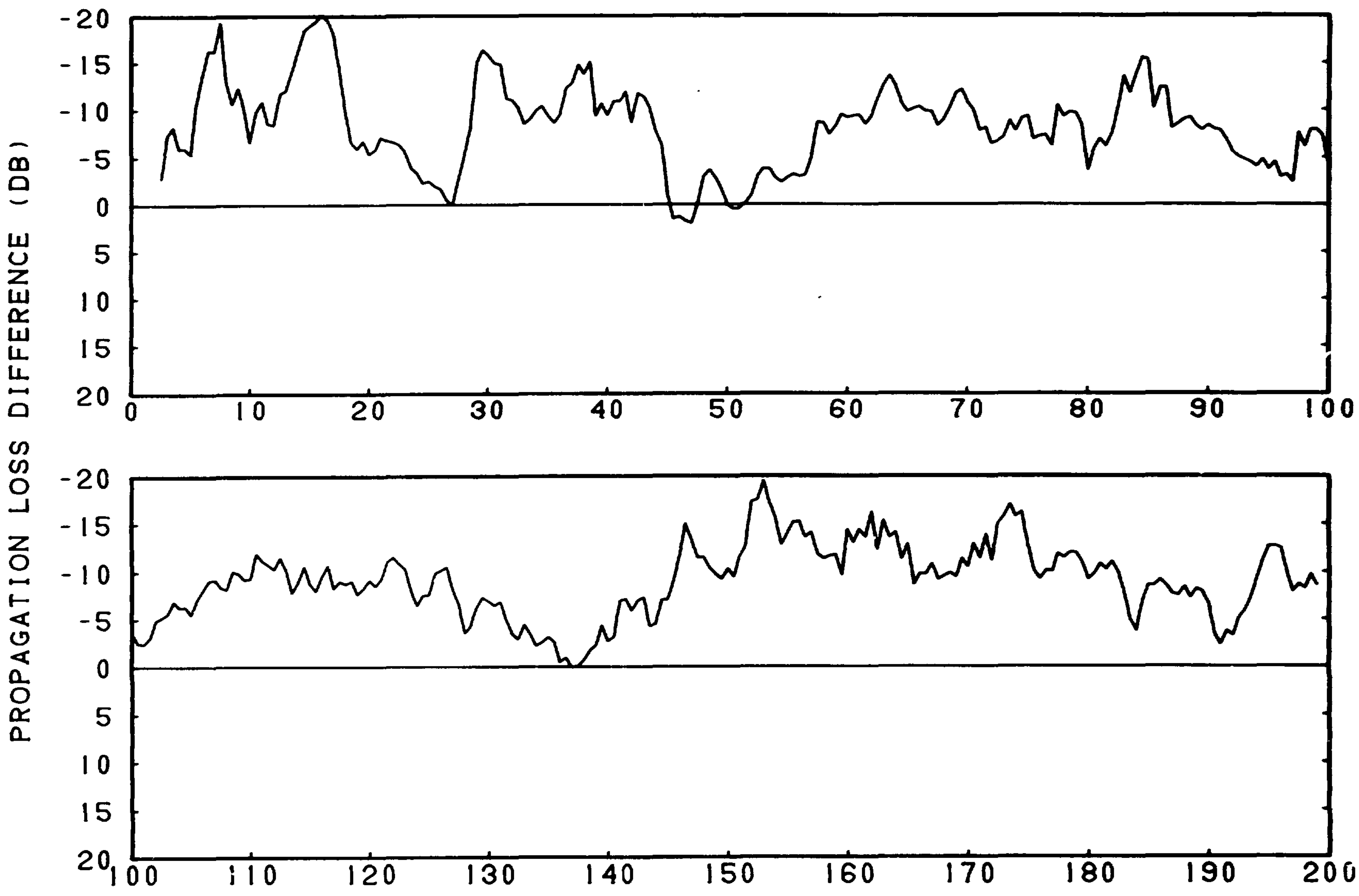
CONFIDENTIAL

(C) Figure IIIB-48. RAYMODE X (Coherent) Case III, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz



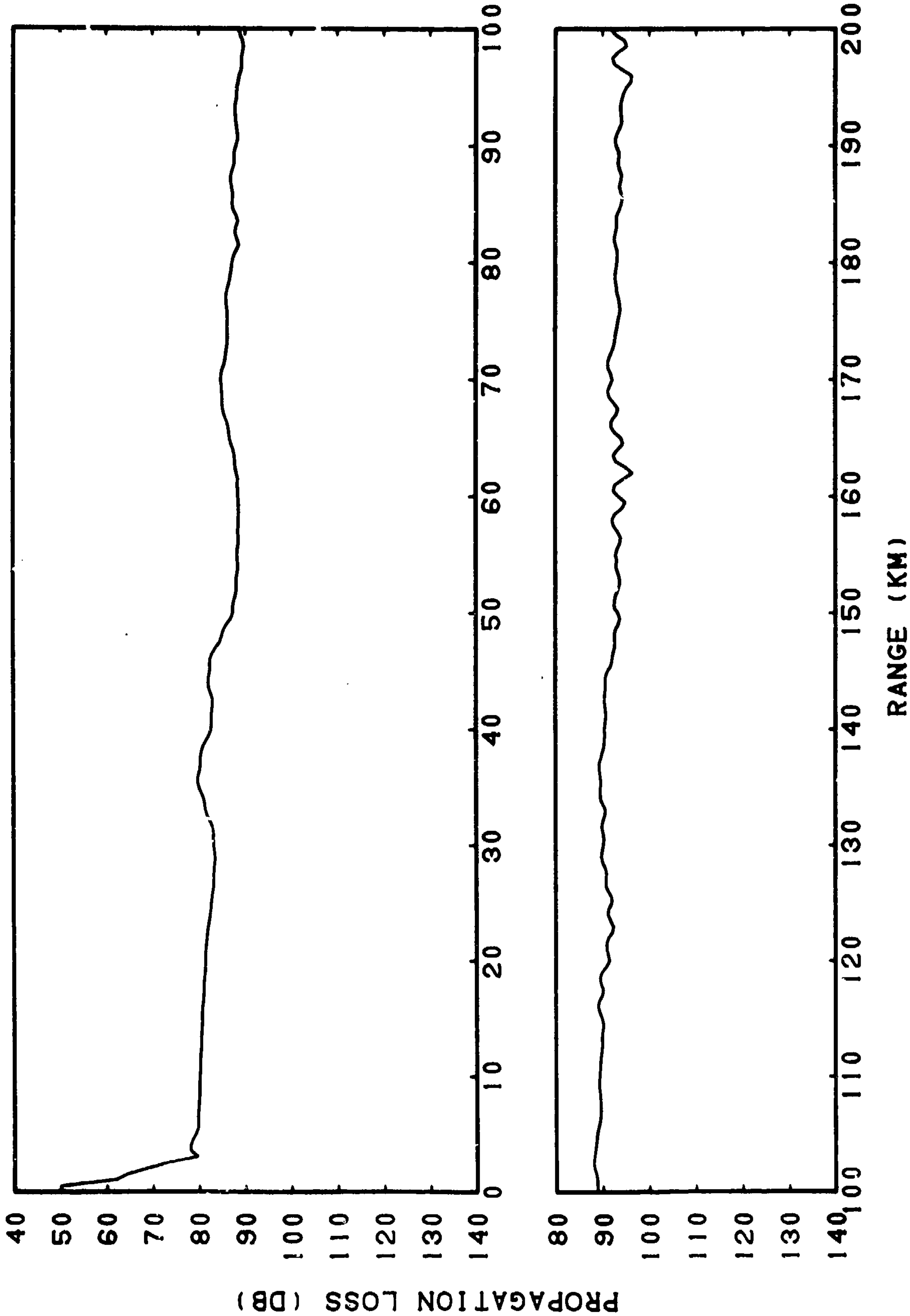
CONFIDENTIAL

(C) Figure IIIB-49. RAYMODE X (Coherent) Case III, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz, Sliding Averages of 5 Points (2.00 Kilometers)



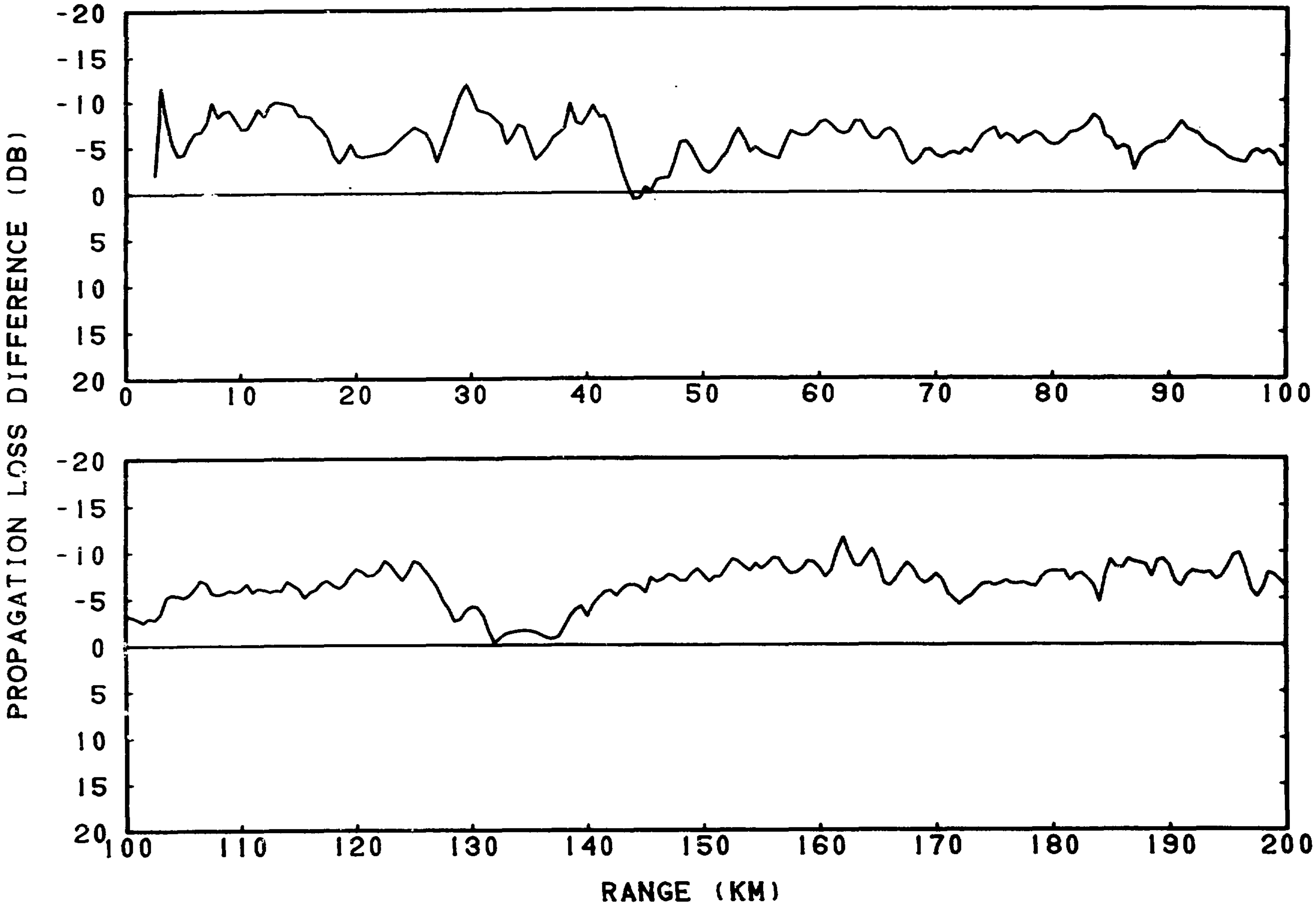
CONFIDENTIAL

(C) Figure IIIB-50. Smoothed RAYMODE X (Coherent) Case III, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz, Subtracted from Hays-Murphy Experimental Data, Case III, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 100 Hertz



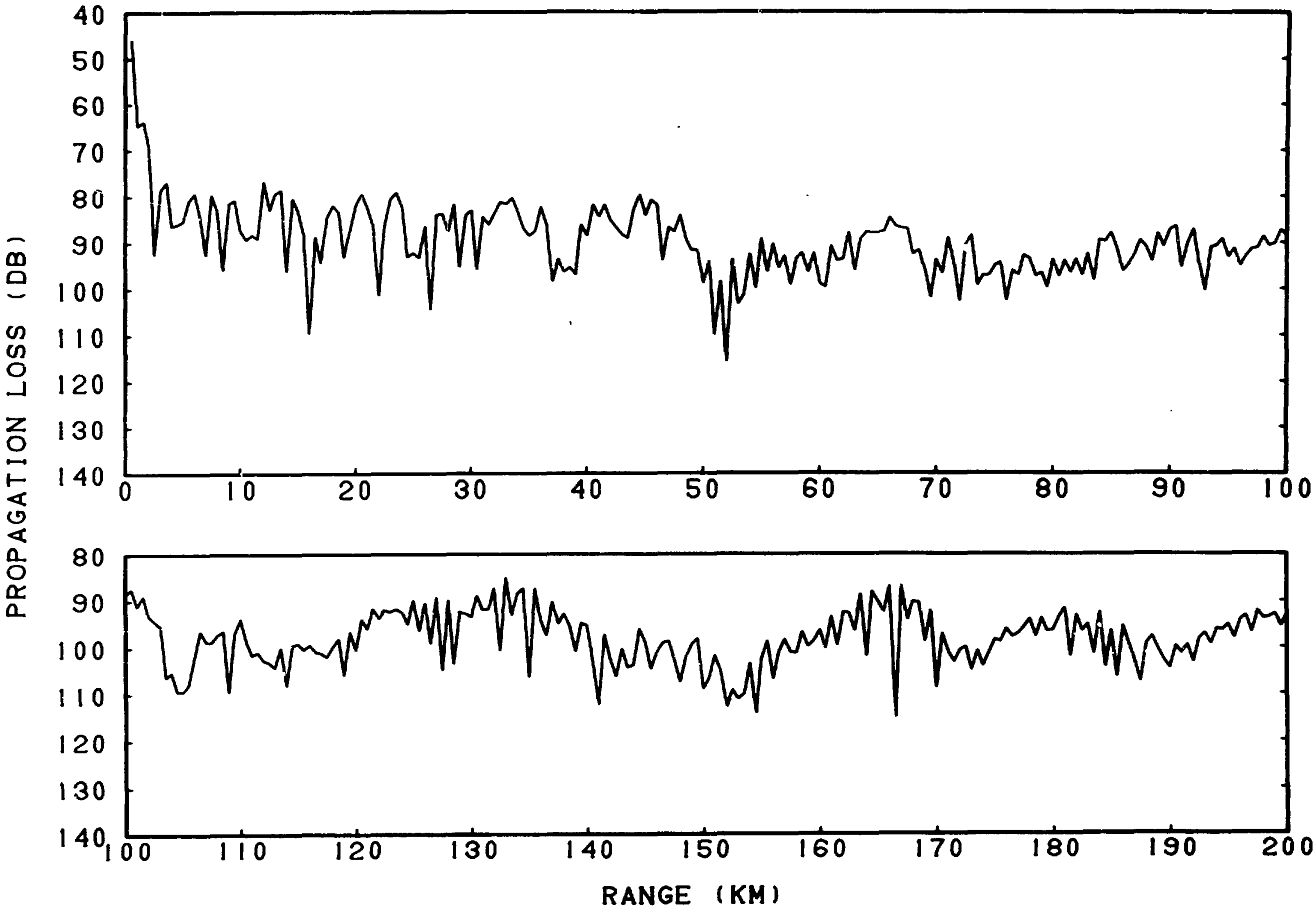
CONFIDENTIAL

(C) Figure IIIB-51. RAYMODE X (Incoherent) Case III, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz



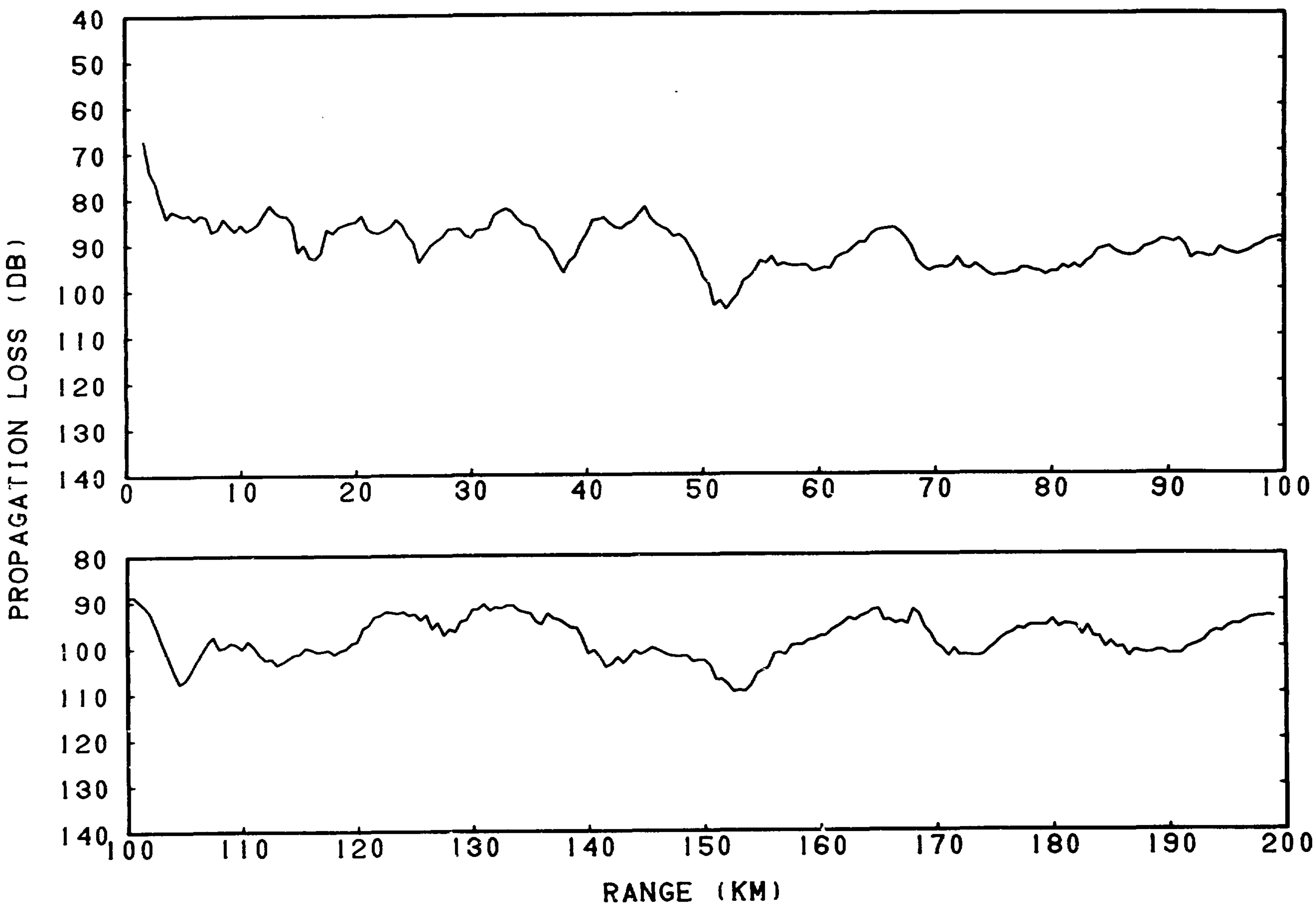
CONFIDENTIAL

(C) Figure IIIB-52. RAYMODE X (Incoherent) Case III, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz, Subtracted from Hays-Murphy Experimental Data, Case III, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 100 Hertz



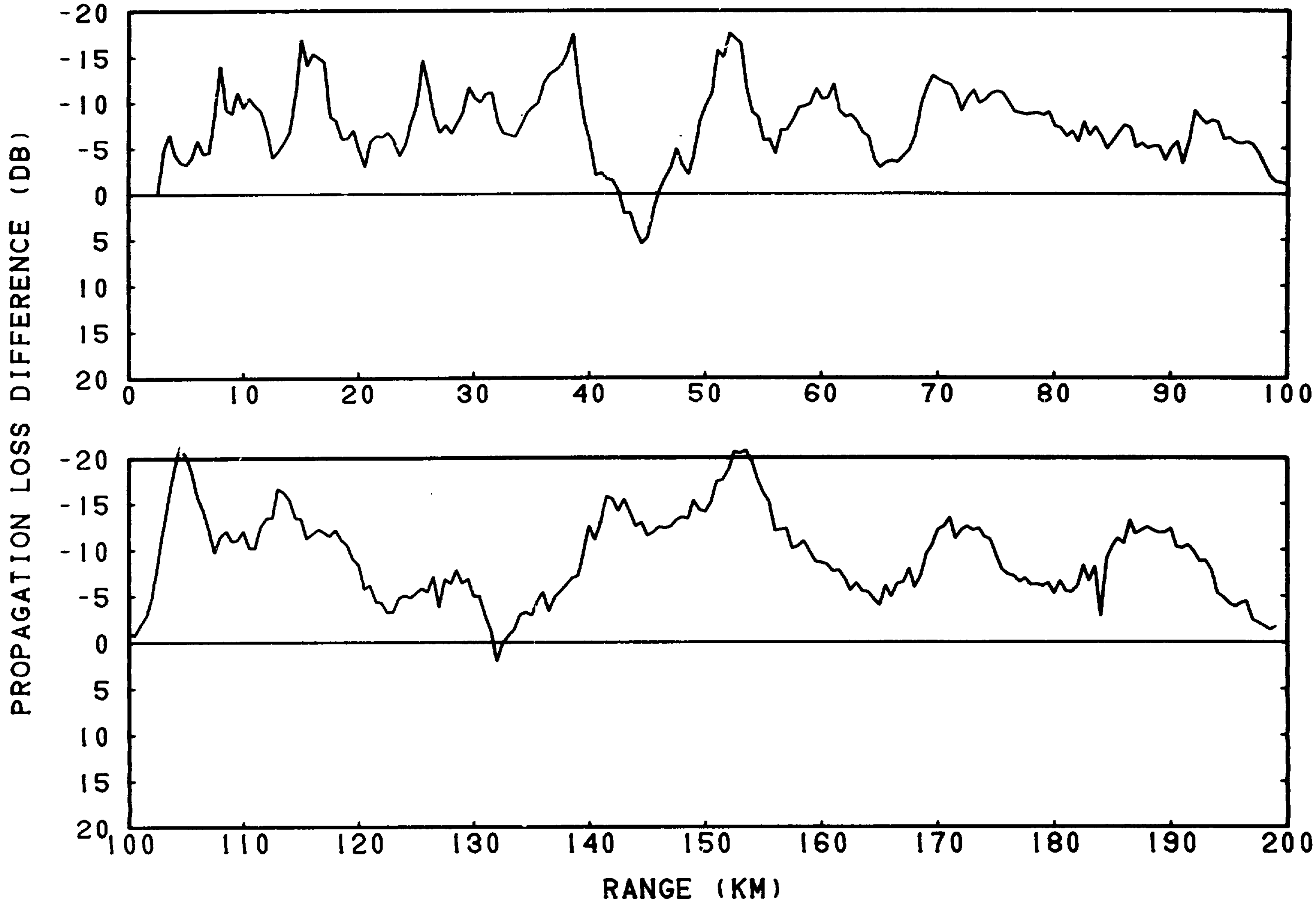
CONFIDENTIAL

(C) Figure IIIB-53. RAYMODE X (Coherent) Case IV, Bottom Loss = FNOC Type 3, Frequency = 200 Hertz



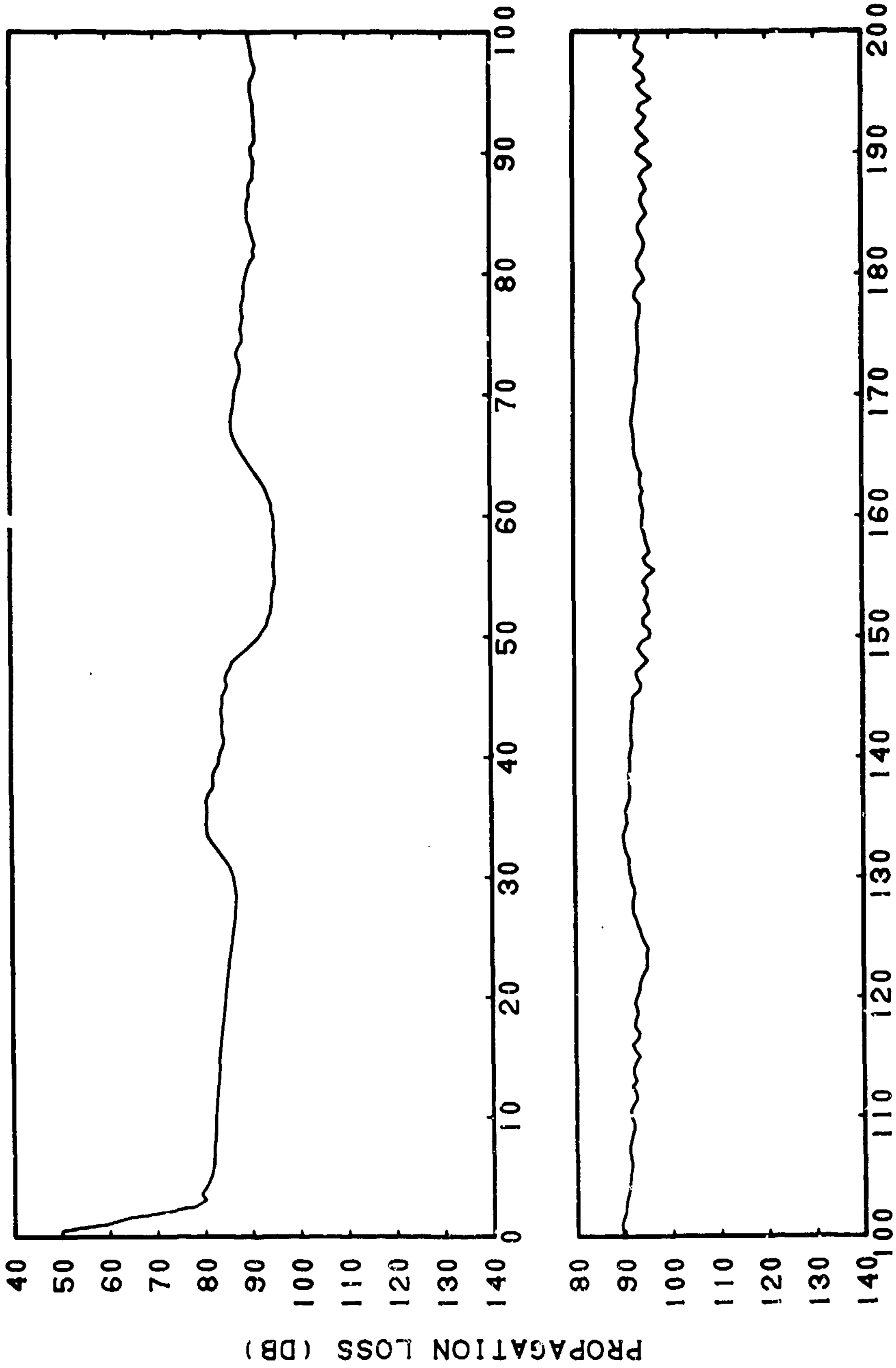
CONFIDENTIAL

(C) Figure IIIB-54. RAYMODE X (Coherent) Case IV, Bottom Loss = FNOC Type 3, Frequency = 200 Hertz, Sliding Averages of 5 Points (2.00 Kilometers)



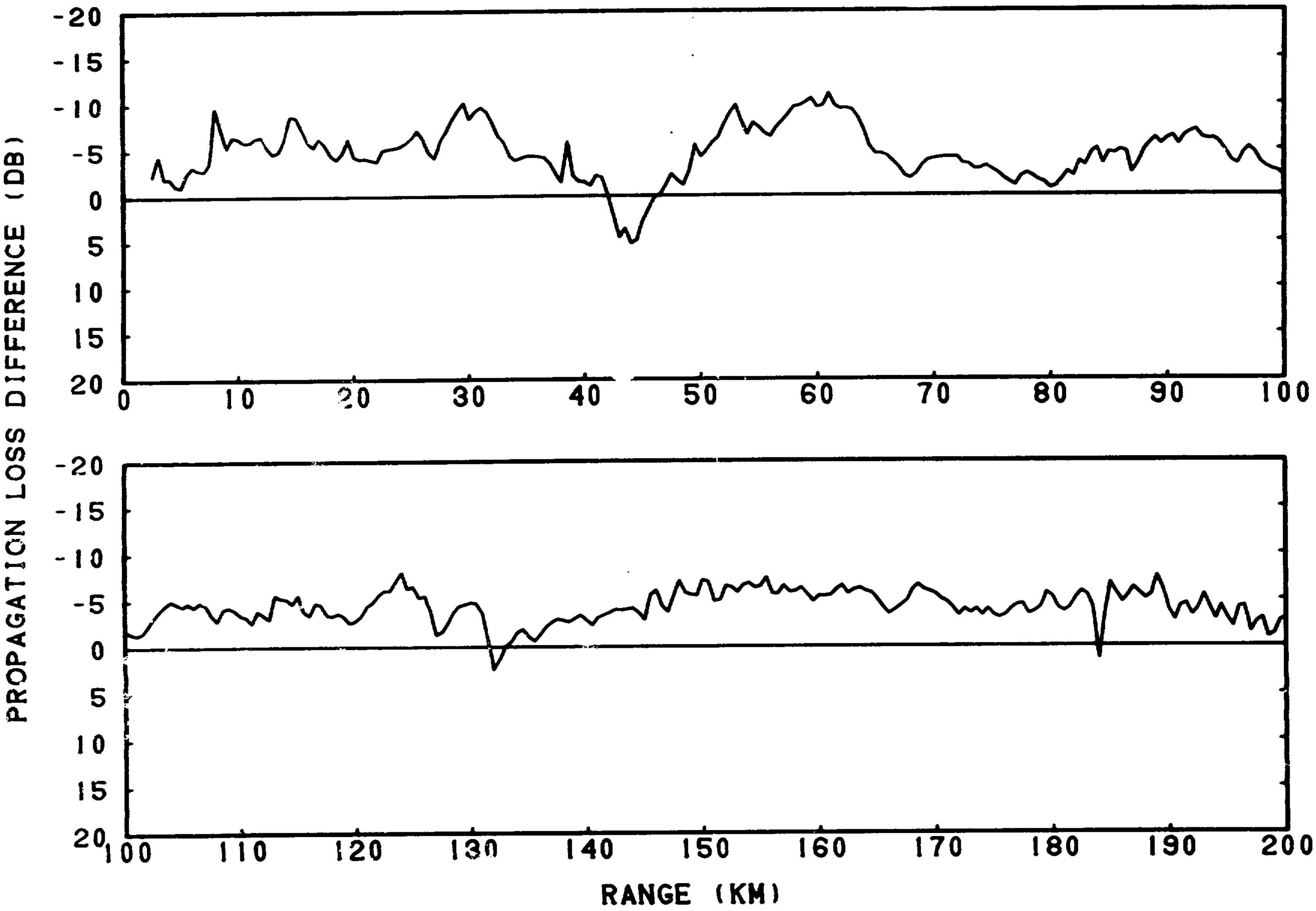
CONFIDENTIAL

(C) Figure IIIB-55. Smoothed RAYMODE X (Coherent) Case IV, Bottom Loss = FNOC Type 3, Frequency = 200 Hertz, Subtracted from Hays-Murphy Experimental Data, Case IV, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 200 Hertz



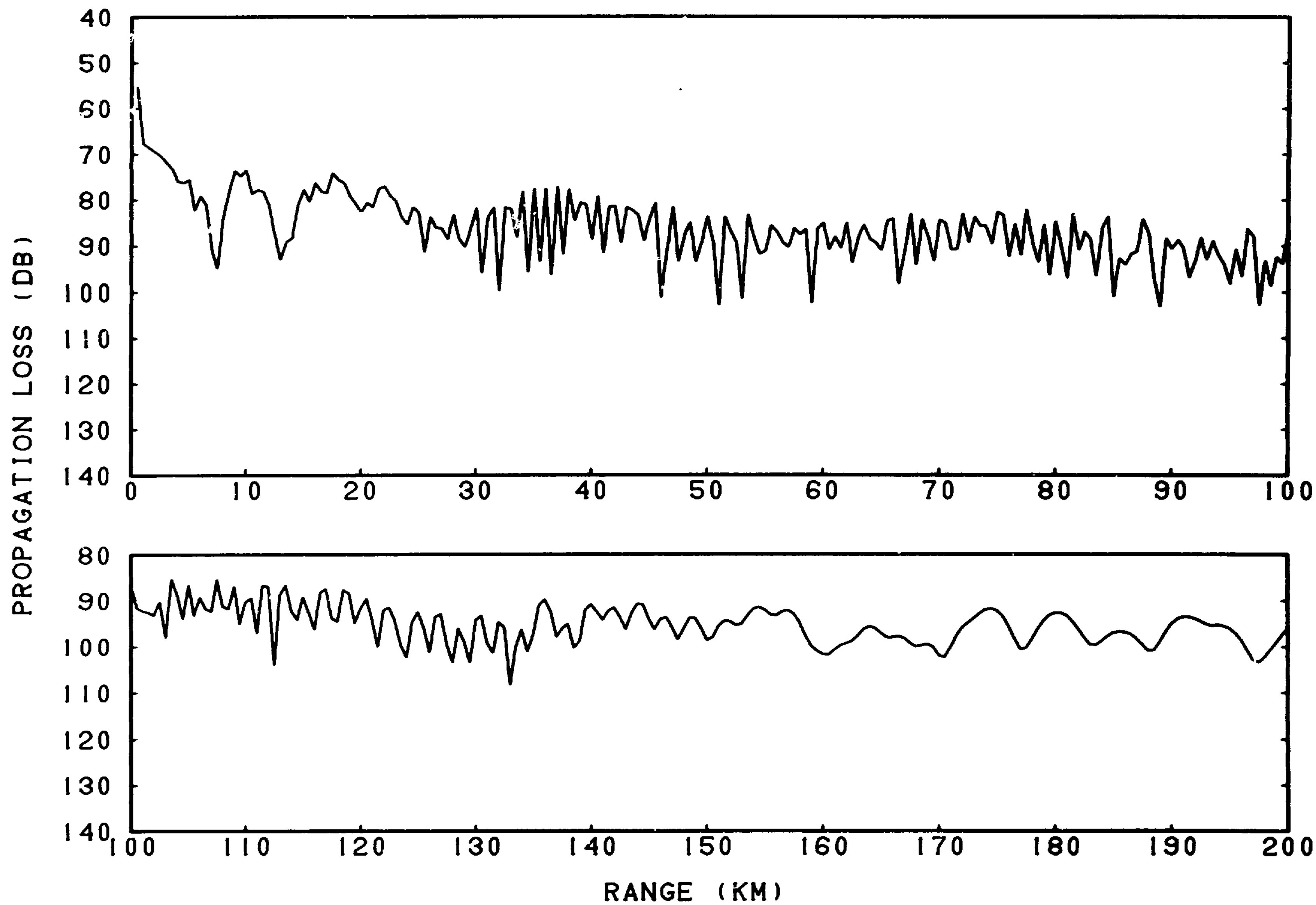
CONFIDENTIAL

(C) Figure IIIB-56. RAYMODE X (Incoherent) Case IV, Bottom Loss = FNOC Type 3, Frequency = 200 Hertz



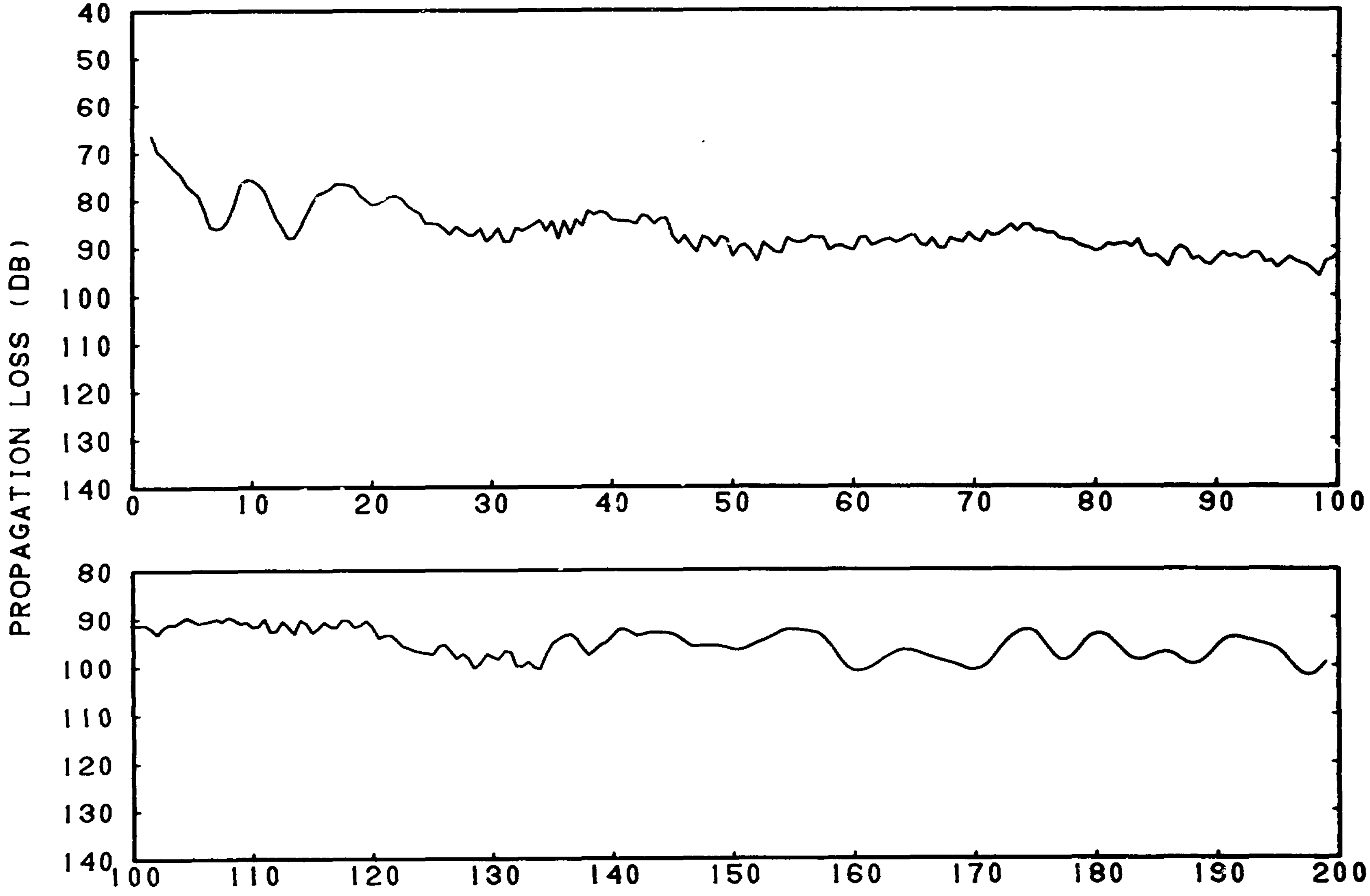
CONFIDENTIAL

(C) Figure IIIB-57. RAYMODE X (Incoherent) Case IV, Bottom Loss = FNOC Type 3, Frequency = 200 Hertz, Subtracted from Hays-Murphy Experimental Data, Case IV, Source Depth = 80 Feet, Receiver Depth = 450 Feet, Frequency = 200 Hertz



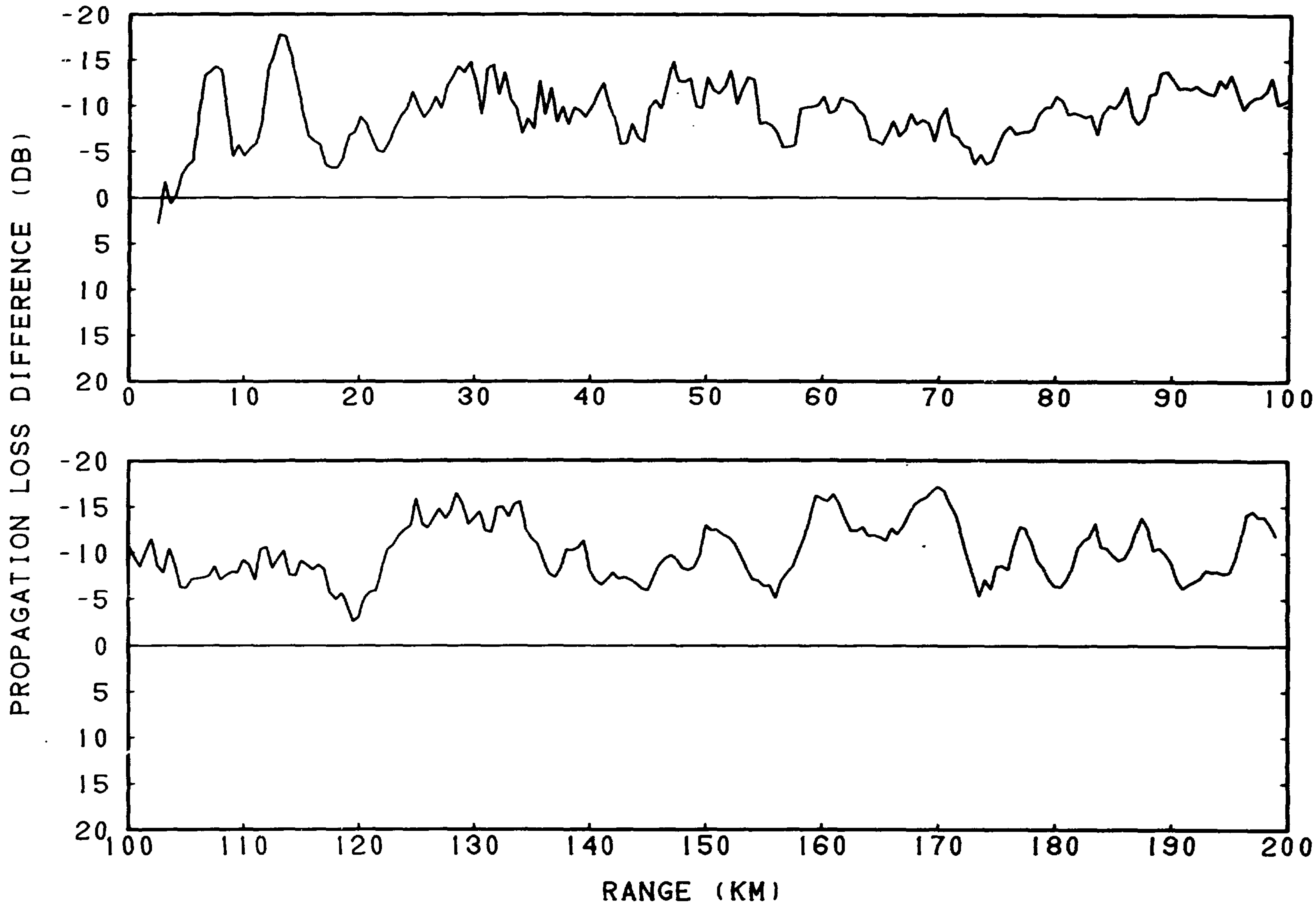
CONFIDENTIAL

(C) Figure IIIB-58. RAYMODE X (Coherent) Case V, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz



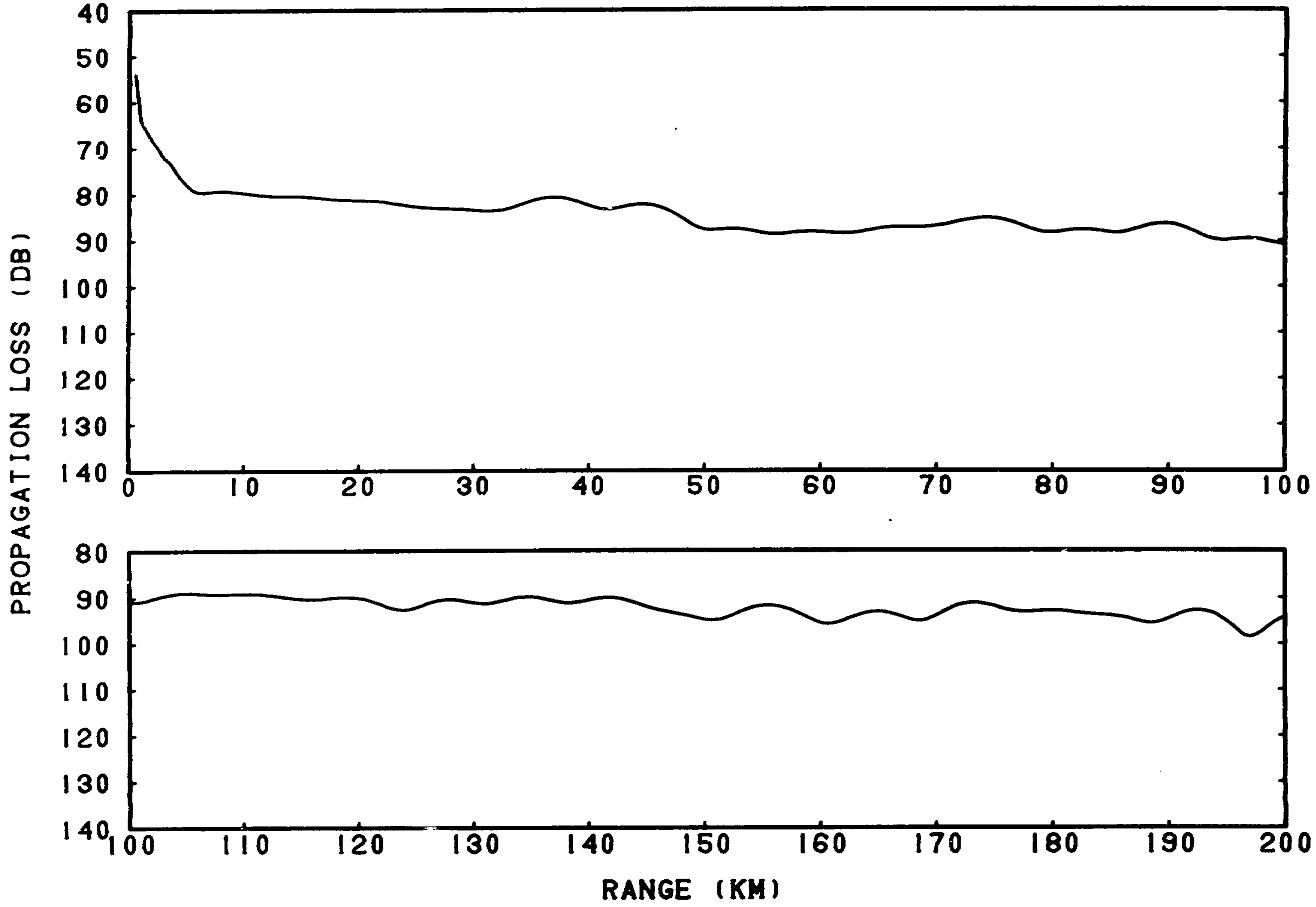
CONFIDENTIAL

(C) Figure IIIB-59. RAYMODE X (Coherent) Case V, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz, Sliding Averages of 5 Points (2.00 Kilometers)



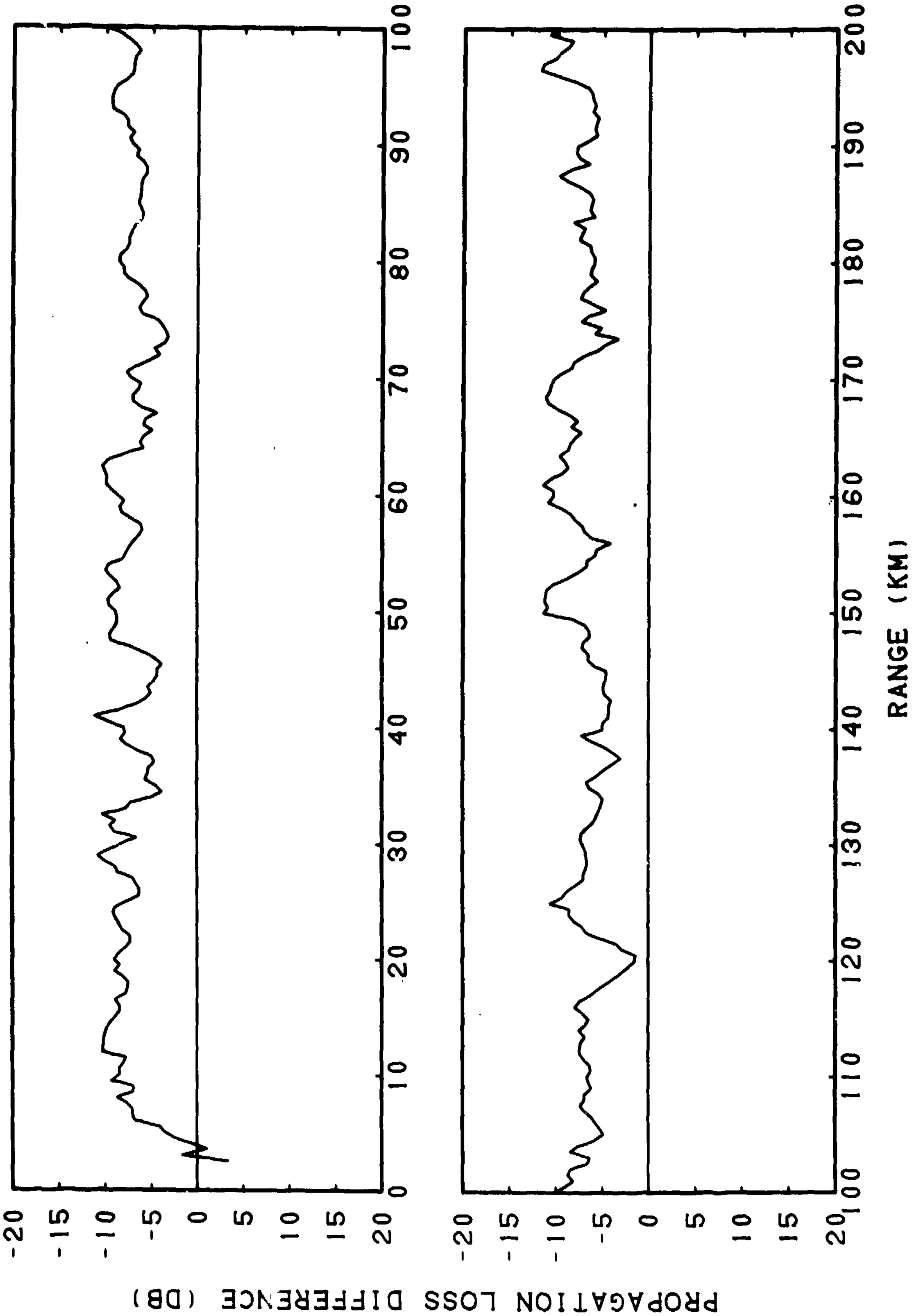
CONFIDENTIAL

(C) Figure IIIB-60. Smoothed RAYMODE X (Coherent) Case V, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz, Subtracted from Hays-Murphy Experimental Data, Case V, Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 35 Hertz



CONFIDENTIAL

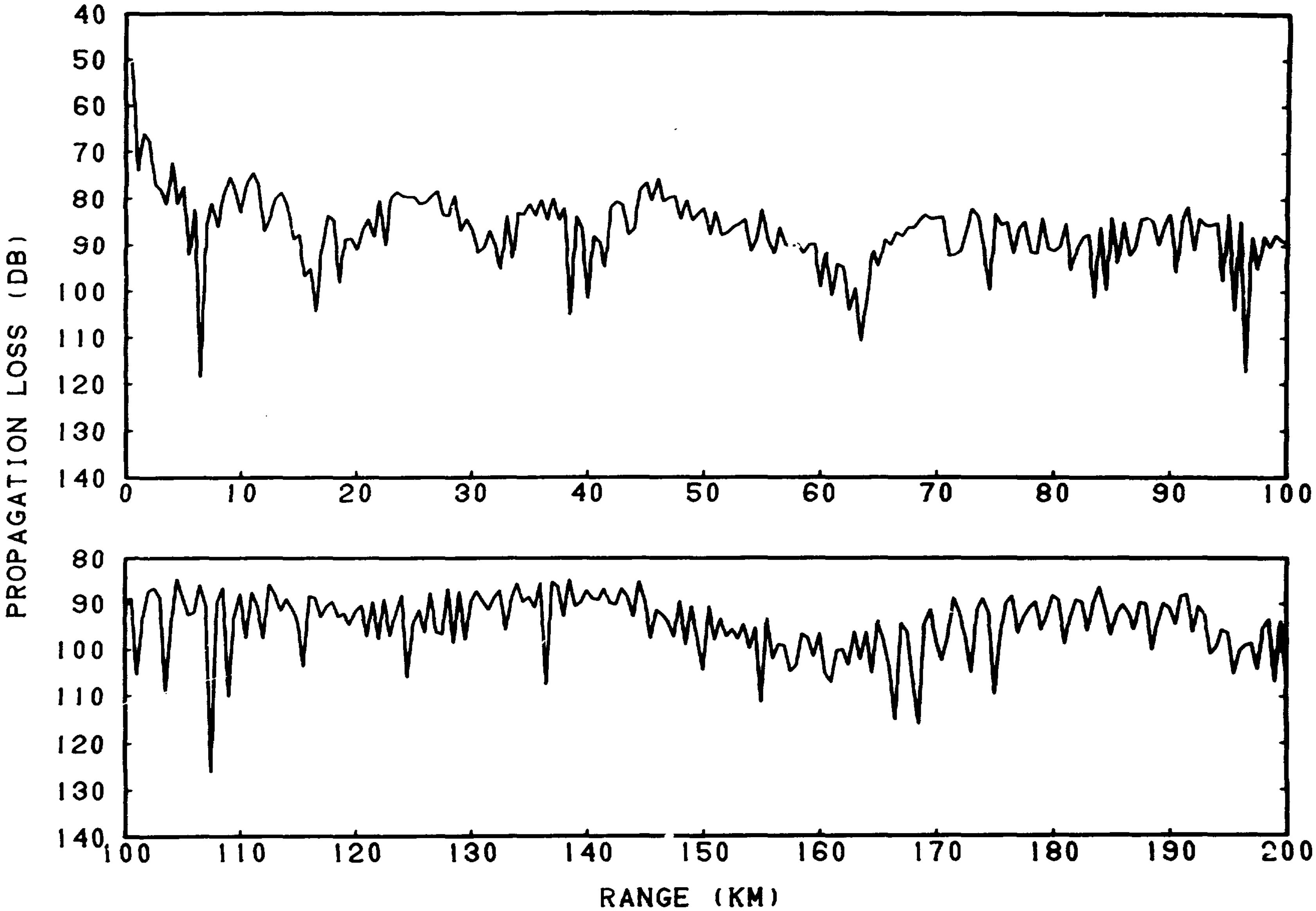
(C) Figure IIIB-61. RAYMODE X (Incoherent) Case V, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz



CONFIDENTIAL

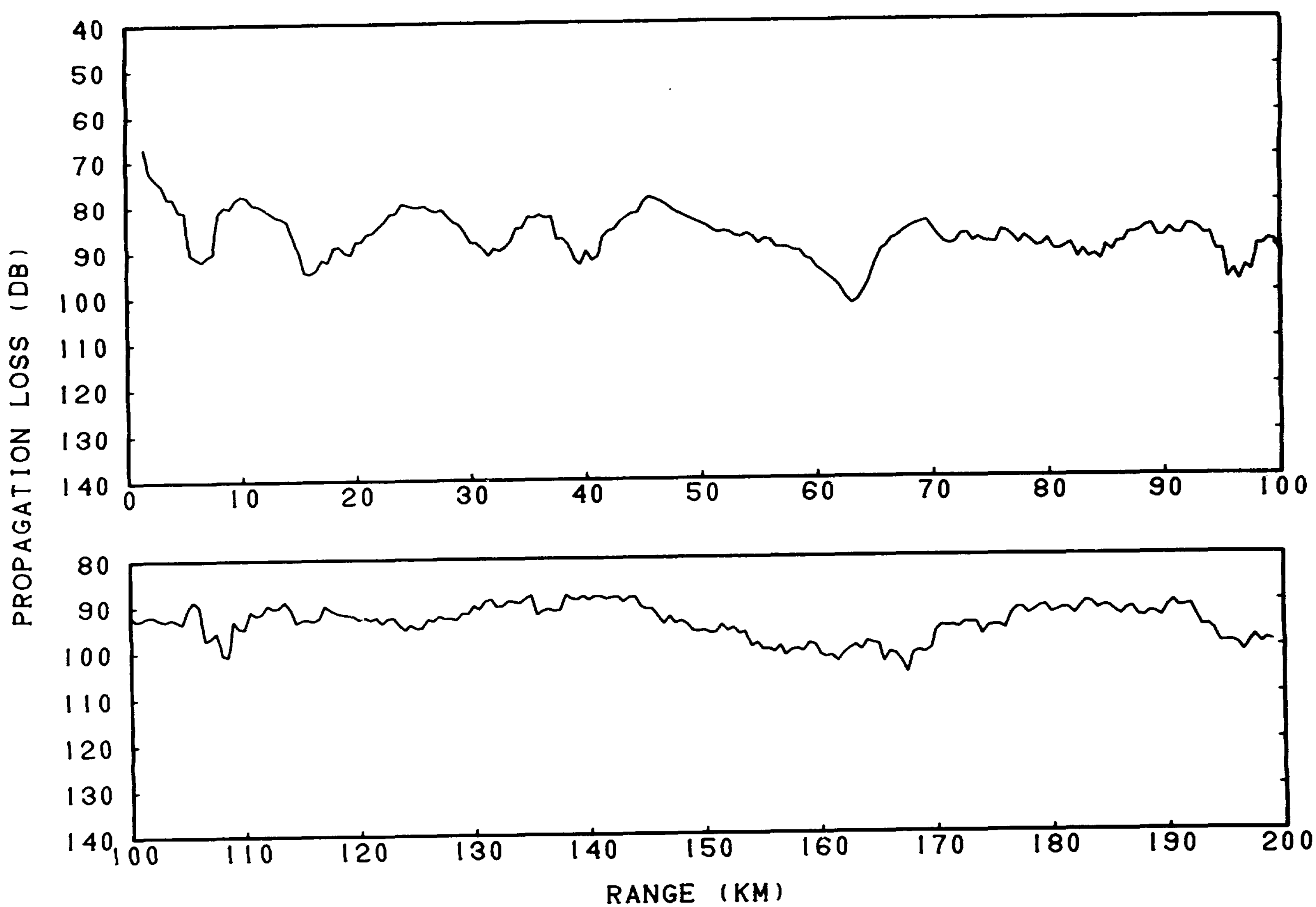
(C) Figure IIIB-62. RAYMODE X (Incoherent) Case V, Bottom Loss = FNOC Type 3, Frequency = 35 Hertz, Subtracted from Hays-Murphy Experimental Data, Case V Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 35 Hertz

CONFIDENTIAL



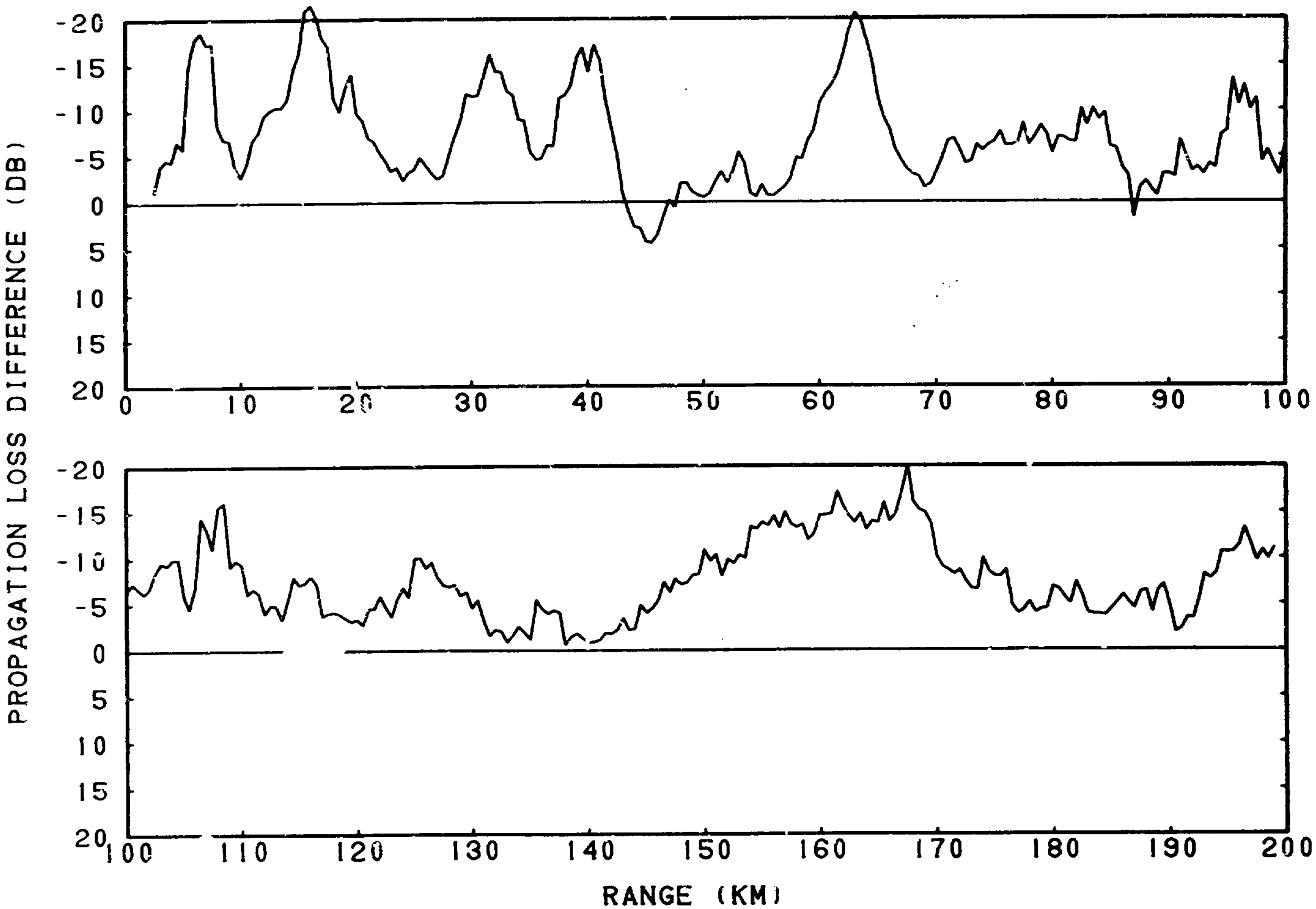
CONFIDENTIAL

(C) Figure IIIB-63. RAYMODE X (Coherent) Case VI, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz



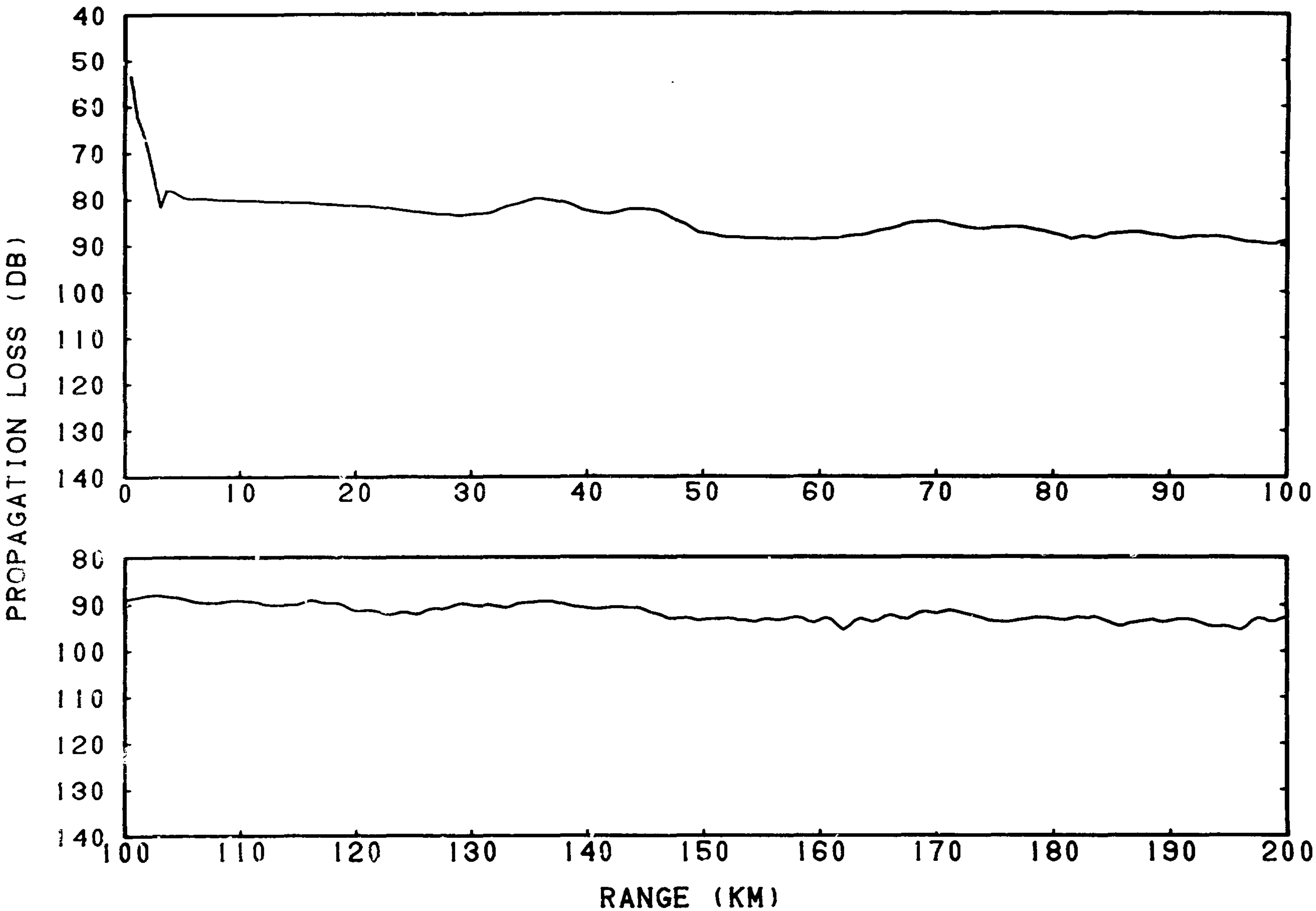
CONFIDENTIAL

(C) Figure IIIB-64. RAYMODE X (Coherent) Case VI, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz, Sliding Averages of 5 Points (2.00 Kilometers)



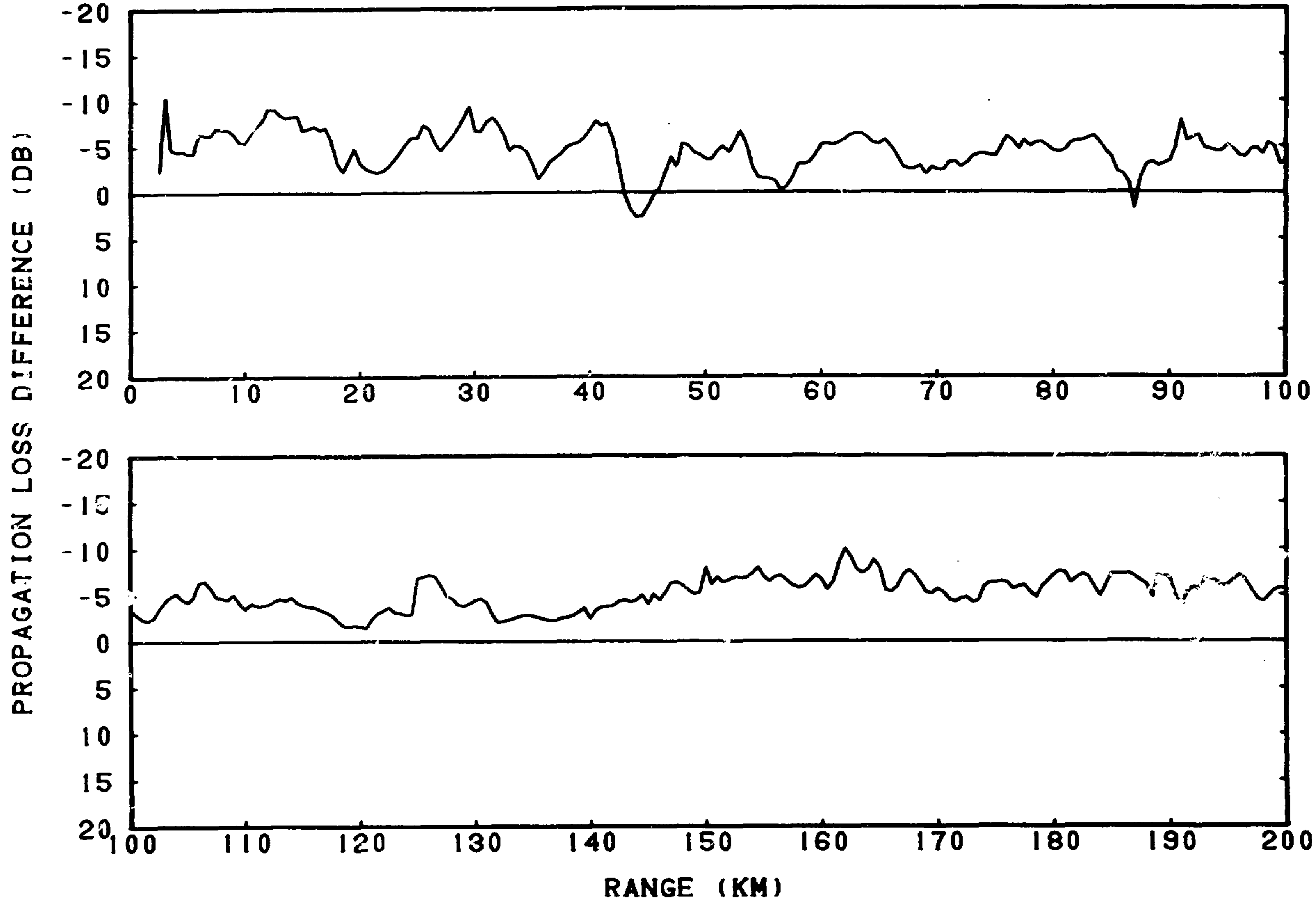
CONFIDENTIAL

(C) Figure IIIB-65. Smoothed RAYMODE X (Coherent) Case VI, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz, Subtracted from Hays-Murphy Experimental Data, Case VI, Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 100 Hertz



CONFIDENTIAL

(C) Figure IIIB-6C. RAYMODE X (Incoherent) Case VI, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz



CONFIDENTIAL

(C) Figure IIIB-67. RAYMODE X (Incoherent) Case VI, Bottom Loss = FNOC Type 3, Frequency = 100 Hertz, Subtracted from Hays-Murphy Experimental Data, Case VI, Source Depth = 80 Feet, Receiver Depth = 350 Feet, Frequency = 100 Hertz

Appendix IIIC. Accuracy Assessment of RAYMODE X Compared to PARKA Experimental Data (U)

PARKA (U)

Environment (U)

(C) The sound speed profile for the PARKA environment is plotted and tabulated in Figure IIC1. This profile exhibits a surface duct to a depth of 262 ft (80 m) and a deep sound channel to a depth of 14594 ft (4448 m). The positive depth excess is 3452 ft (1052 m).

(C) Two sets of bottom loss tables were used as input to the RAYMODE X model. The first is RAYMODE's internal MGS bottom loss found in subroutine MGSBL, and in the two cases examined, a type 6 bottom was found to pertain at the site of the receiver. The second set of curves are the FNOC/NOO curves found in subroutine BTMLOS in the FACT PL9D model; and here a type 3 bottom was found from the bottom loss province charts. The latter curves were input into RAYMODE X from an external table of 91 values. The MGS curves for 50 and 400 Hz are found in Figures IIIC-2 and IIIC-3 and Tables IIIC-1 and IIIC-2. The corresponding FNOC/NOO curves are presented in Figures IIIC-4 and IIIC-5 and Tables IIIC-3 and IIIC-4. At 50 Hz, RAYMODE X's MGS bottom loss has a critical angle of 9°, 1.6 dB loss at 15° and 8.1 dB loss at normal incidence. The FNOC/NOO results at 50 Hz has a critical angle of 12°, a 1 dB loss at 15°, and 10 dB loss at normal incidence. At 400 Hz, the RAYMODE X internal MGS curve shows a 7.5 dB loss at zero degrees, 11.3 dB at 15°, and 15.9 dB at normal incidence. FNOC/NOO results for 400 Hz show a constant 3 dB loss to 14°, 3.3 dB at 15°, and 11 dB at normal incidence.

Test Cases (U)

(C) Two test cases were chosen for the PARKA environment:

Case I. Source Depth = 500 ft (152.4 m), Receiver Depth = 300 ft (91.4 m), Frequency = 50 Hz.

Case II. Source Depth = 500 ft (152.4 m), Receiver Depth = 300 ft (91.4 m), Frequency = 400 Hz.

(C) For both cases, source and receiver are below the surface duct. Due to the large depth excess, convergence zone (CZ) propagation is exhibited by the PARKA data in both cases; in Case I, three convergence zones were observed and in Case II, two zones were observed (range was sufficient for a third zone but it was not evident). In both cases, the flat bottom and single profile assumptions inherent in the RAYMODE X model held to a range of 200 km. The PARKA experimental data for these cases are found in Figures IIC6 and IIC7.

Accuracy Assessment Results (U)

(U) The accuracy assessment procedures were followed as outlined in section 1.1 and described in detail in Volume I of this series. The following types of figures were produced for each case. (1) RAYMODE X output using the coherent option, (2) the coherent result smoothed by application of a 2 kilometer window running average, (3) the smoothed coherent result subtracted from PARKA, (4) RAYMODE X output using the incoherent phase option, and (5) the incoherent result subtracted from PARKA data. For each case, these five curves are first given for RAYMODE X run with its own internal MGS bottom loss and then for RAYMODE X run using FACT PL9D's FNOC/NOO bottom loss curves. These results are given in Figures IIIC-8-17 for Case I and Figures IIIC-18-27 for Case II.

(U) The means and standard deviations of differences between PARKA data and RAYMODE X outputs in dB for which the model used the MGS bottom loss are given in Table IIIC-5 for Case I and Table IIIC-6 for Case II. Corresponding results for which the FNOC/NOO bottom loss was used are given in Tables IIIC-7 and IIIC-8. Note that a positive mean value of difference indicates that the model exhibits less loss than the PARKA experimental data and is too optimistic; conversely, a negative mean value of difference indicates greater loss for model result than for experimental data and the model prediction is therefore too pessimistic. Optimistic model results translate into prediction of detection ranges which are greater than should be predicted (i.e., greater than the experimental results) and vice versa for pessimistic model results.

(C) The following observations can be made with regard to the 50 Hz results (i.e., Case I) from Tables IIIC-5 and IIIC-7 and reference to appropriate figures: (1) The results are quite sensitive to the choice of coherence option with the incoherent option in better agreement with the data (by as much as 4.8 dB upon comparing the sum $\mu + \sigma$ for incoherent and coherent results) in most regions. The picture is not, however, all one sided; in the second and third bottom bounce regions the coherent option shows slight advantage over the incoherent of 0.7 and 0.9 dB, respectively, when viewed in terms of $\mu + \sigma$. (2) The RAYMODE and FACT bottom loss options lead to differences ranging from 0 to 1.8 dB in values of μ or σ. The use of MGS bottom loss results in better agreement between RAYMODE output and PARKA data through the second bottom bounce region and in the third bottom bounce region than does the use of the FNOC bottom loss for both coherence options. The two bottom loss tables differ by 0 dB to a grazing angle of 9 degrees and by less than 1 dB thereafter. It is therefore not surprising that the effects of changing bottom loss in RAYMODE X did not lead to large discrepancies in comparisons with PARKA data. (3) Agreement between PARKA data and RAYMODE X with the incoherent phase option is $\mu = -1.1$, $\sigma = 2.9$ for the first convergence zone, $\mu = 3.5$, $\sigma = 3.8$ for the second convergence zone, and $\mu = -6.4$, $\sigma = 2.6$ for the third convergence zone. Thus, we see a lessening of agreement with each successive zone, a trend one would expect. (4) In the bottom bounce regions, the RAYMODE X model results are consistently optimistic; clearly, the bottom loss was not great enough (i.e., a higher bottom type is indicated for the FNOC area charts whereas for MGS only one bottom loss curve exists at 50 Hz regardless of bottom type and therefore a basic problem is found for the MGS bottom loss data base). We note the increasing discrepancy between experimental data and model prediction with range as indicated by the increase of μ with range in bottom bounce regions. No clear trend emerges, however, for the behavior of the standard deviation with range in bottom bounce regions.

(C) For Case II (400 Hz) the means and standard deviations of the difference curves (PARKA experimental data minus RAYMODE X predictions) found in Tables IIIC-6 and IIIC-8 lead to the following conclusions: (1) The FNOC bottom loss results in better agreement with the data than does the use of MGS bottom loss information (Note: This conclusion should not be generalized to other environments or frequency regions) (2) For the MGS bottom loss the model results are generally pessimistic as seen in Table IIIC-6 by the negative values for μ. This changes to slight optimism upon using the FNOC bottom loss curves with mean values varying from 1.9 to 2.8 dB. (3) The large standard deviation in the region from 127.5 to 200 kilometers is due to the RAYMODE X prediction of the third convergence zone which was not evident in the PARKA data.

(C) The figure of merit (FOM) versus detection range analyses for the two cases are given in Tables IIIC-9 and IIIC-10, respectively, for the RAYMODE X model

using the internal MGS bottom loss. Corresponding Tables IIIC-11 and IIIC-12 apply to use of the FNOC/NOO bottom loss in RAYMODE X. For Case I, the following results are observed from Table IIIC-9: (1) For FOM = 80 dB, the PARKA data shows a double-lobed first convergence zone whereas the RAYMODE X prediction does not. (2) For FOM = 85 dB, both PARKA and RAYMODE X (coherent) have a double-lobed first convergence zone. Although the zone end is predicted accurately by RAYMODE, zone onset is at two or three kilometers greater range than PARKA gives, for coherent and incoherent predictions, respectively. RAYMODE predicts a second convergence zone with an onset at about 5 km greater range than the PARKA data indicate. The third convergence zone predicted by RAYMODE is not present in the PARKA data for an FOM of 85 dB. (3) For FOM = 90 dB, the RAYMODE prediction is optimistic with regard to the PARKA data. The onset of the first CZ is long by 2 km, the onset of the second CZ is long by 5 km as is the zone end. The third CZ onset is at 15 km greater range for RAYMODE than for PARKA data. (4) For FOM = 95 dB, the RAYMODE model predicts better detection performance than that observed from PARKA data, has a cont[illegible]ous coverage range which extends to beyond the first CZ, and predicts a second CZ onset 9 km beyond PARKA's result. The third CZ onset and end ranges are greater for RAYMODE than for PARKA. There is also substantial difference between the second and third CZs predicted by RAYMODE with coherent phase and RAYMODE with incoherent phase. In both cases, the bottom bounce energy is evident at the zone onset in the form of fluctuations in the coherent result. (5) For FOM = 100 dB, the RAYMODE prediction is again optimistic with respect to PARKA. Indeed, RAYMODE incoherent predicts continuous coverage over the entire range extent of 200 km. (6) For FOM = 105 dB, coverage is essentially continuous with the only difference being a zone of no detection between 149 and 155 for PARKA.

(C) For Case II (400 Hz) the following are observed from reference to Table IIIC-10 and the figures: (1) For FOM = 80 dB, the RAYMODE prediction shows a first convergence zone whereas the PARKA data does not. (2) For FOM = 85 dB, the RAYMODE model predicts a convergence zone elongated at start and end when compared to PARKA data; 2 km short at the start and 4 km long at the end. (3) For FOM = 90 dB, the start range of the first CZ is the same for RAYMODE and PARKA; the end of the zone is, however, elongated by 5 km. PARKA data shows second and third CZ coverage as does RAYMODE. The incoherent RAYMODE prediction for the second CZ starts at the same range as PARKA but ends 5 km farther. The third CZ start for RAYMODE is 13 km beyond that for PARKA and the end is 7 km farther. (4) For FOM = 95 dB, the coverage for PARKA is continuous to 50 km; for RAYMODE, the coverage is zonal at 35% between 10 and 50 km. The first CZ is essentially the same for PARKA and RAYMODE. The second CZ start is shifted by 3 km greater range for RAYMODE as compared to PARKA; the CZ ends are identical. The third CZ predicted by RAYMODE is not found in PARKA data. (5) For FOM = 100 dB, PARKA shows continuous coverage to 69 km and RAYMODE to 70 km, the end of the first CZ. PARKA shows low (15%) coverage between first and second CZs; RAYMODE shows no coverage in this region; the second CZ onset is at 4 km less range for PARKA than for RAYMODE. Beyond the second CZ, PARKA shows no coverage but RAYMODE has a broad third CZ. (6) For FOM = 105 dB, PARKA shows continuous coverage to the end of the second CZ whereas RAYMODE has no coverage between the first and second CZs. The end of the second CZ is at 129 km for PARKA and 133 km for RAYMODE incoherent. Beyond the second CZ, RAYMODE and PARKA coverage are zonal to 183 km where PARKA coverage ends; RAYMODE coverage continues to 195 km including a third CZ. (7) For FOM = 110 dB, PARKA coverage is continuous to 188 km. RAYMODE coverage over this interval is

largely zonal past the first convergence zone and drops out in the third bottom bounce region.

(C) Overall, the following results are given for the comparison between PARKA experimental data and the RAYMODE X model: (1) The FNOC/NOO bottom loss leads to better agreement than does the MGS bottom loss. (2) At 50 Hz, the PARKA data and RAYMODE predictions agree well (near the RAYMODE coherent peaks) in the first bottom bounce region and agree well in the middle of the second bottom bounce region. In the third bottom bounce region, the RAYMODE prediction shows less loss than the PARKA data. This is in contrast to the 400 Hz results for which PARKA shows significantly less loss in all bottom bounce regions compared to RAYMODE. (3) At 50 Hz, the first convergence zone as predicted by RAYMODE is in very good agreement with that of PARKA but slightly wider. The second RAYMODE CZ is found at shorter range than is PARKA's by about 5 km; this situation is exaggerated in the case of the third convergence zone. At 400 Hz, the results for the first and second CZ starts are basically the same. The RAYMODE first CZ is wider than RAYMODE's and the second is narrower.

(U) Table IIIC-1. Bottom Loss (dB) versus Grazing Angle (degrees). MGS Type 6. Frequency = 50 Hz.

Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL
0	0	13	1.36	26	4.49	39	6.57	52	7.84	65	8.45	78	8.51
1	0	14	1.64	27	4.68	40	6.70	53	7.91	66	8.47	79	8.49
2	0	15	1.92	28	4.87	41	6.82	54	7.97	67	8.49	80	8.48
3	0	16	2.19	29	5.05	42	6.93	55	8.03	68	8.51	81	8.45
4	0	17	2.45	30	5.23	43	7.04	56	8.09	69	8.52	82	8.43
5	0	18	2.70	31	5.40	44	7.15	57	8.14	70	8.53	83	8.40
6	0	19	2.95	32	5.57	45	7.25	58	8.19	71	8.54	84	8.37
7	0	20	3.19	33	5.73	46	7.34	59	8.24	72	8.55	85	8.33
8	0	21	3.42	34	5.88	47	7.44	60	8.28	73	8.55	86	8.30
9	0.14	22	3.65	35	6.03	48	7.53	61	8.32	74	8.55	87	8.26
10	0.46	23	3.87	36	6.17	49	7.61	62	8.36	75	8.54	88	8.21
11	0.77	24	4.08	37	6.31	50	7.69	63	8.39	76	8.54	89	8.17
12	1.07	25	4.29	38	6.45	51	7.77	64	8.42	77	8.52	90	8.12

UNCLASSIFIED

(U) Table IIIC-2. Bottom Loss (dB) versus Grazing Angle (degrees). MGS Type 6. Frequency = 400 Hz.

Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL
0	7.50	13	11.15	26	13.12	39	14.39	52	15.20	65	15.69	78	15.91
1	8.37	14	11.34	27	13.24	40	14.46	53	15.25	66	15.72	79	15.92
2	8.85	15	11.52	28	13.35	41	14.54	54	15.30	67	15.74	80	15.92
3	9.19	16	11.69	29	13.46	42	14.61	55	15.34	68	15.76	81	15.93
4	9.44	17	11.86	30	13.57	43	14.68	56	15.38	69	15.78	82	15.93
5	9.65	18	12.02	31	13.67	44	14.75	57	15.42	70	15.80	83	15.93
6	9.83	19	12.18	32	13.77	45	14.81	58	15.46	71	15.82	84	15.94
7	9.98	20	12.33	33	13.87	46	14.87	59	15.50	72	15.84	85	15.93
8	10.11	21	12.47	34	13.96	47	14.93	60	15.53	73	15.85	86	15.93
9	10.28	22	12.61	35	14.05	48	14.99	61	15.57	74	15.87	87	15.93
10	10.52	23	12.74	36	14.14	49	15.05	62	15.60	75	15.88	88	15.92
11	10.74	24	12.87	37	14.23	50	15.10	63	15.63	76	15.89	89	15.92
12	10.95	25	13.00	38	14.31	51	15.15	64	15.66	77	15.90	90	15.91

UNCLASSIFIED

(U) Table IIIC-3. Bottom Loss (dB) versus Grazing Angle (degrees).
FNOC Type 3. Frequency = 50 Hz.

Θ	BL
0	0
11	0
20	.3
25	4.4
35	6.7
45	8.5
66	10.0
90	10.0

UNCLASSIFIED

(U) Table IIIC-4. Bottom Loss (dB) versus Grazing Angle (degrees).
FNOC Type 3. Frequency = 400 Hz.

Θ	BL
0	3.0
13	3.0
20	5.3
35	8.7
45	10.3
53	11.0
90	11.0

UNCLASSIFIED

(C) Table IIIC-5. Means (μ) and Standard Deviations (σ) of Differences Between PARKA Data and RAYMODE X Model Outputs (in dB). Source Depth = 500 ft., Receiver Depth = 300 ft., Frequency = 50 Hz. MGS (i.e., RAYMODE X's Internal) Type 6 Bottom Loss used in RAYMODE X Model Runs.

	1st Bottom Bounce Region 0-54 km		1st Convergence Zone 54-65 km		2nd Bottom Bounce Region 65-113.5 km		2nd Convergence Zone 113.5 - 120.5 km		3rd Bottom Bounce Region 120.5 - 167.5 km		3rd Convergence Zone 167.5 - 179 km		4th Bottom Bounce Region 179 - 200 km	
Model Output	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
RAYMODE Coherent	-1.6	5.2	-3.5	3.6	1.2	5.4	-5.0	3.2	6.1	5.2	-10.3	3.5	5.7	5.1
RAYMODE Incoherent	2.7	2.1	-1.1	2.9	4.1	3.0	-3.5	3.8	7.7	4.5	-6.4	2.6	9.1	4.2

CONFIDENTIAL

(C) Table IIIC-6. Means (μ) and Standard Deviations (σ) of Differences Between PARKA Experimental Data and RAYMODE X Model Outputs (in dB). Source Depth = 500 ft., Receiver Depth = 300 ft., Frequency = 400 Hz. MGS (i.e., RAYMODE X's Internal) Type 6 Bottom Loss Used in RAYMODE X Model Runs.

	1st Bottom Bounce Region 0-54 km		1st Convergence Zone 54-59.5 km		2nd Bottom Bounce Region 59.5-107 km		2nd Convergence Zone 107-127.5 km		127.5 200 km	
Model Output	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
RAYMODE Coherent	-5.9	2.4	1.0	3.1	-5.8	6.2	-2.1	4.6	-1.4	9.5
RAYMODE Incoherent	-4.7	1.5	0.4	1.8	-5.0	6.3	-2.5	5.4	-0.6	10.2

CONFIDENTIAL

(C) Table IIIC-7. **Means (μ) and Standard Deviations (σ) of Differences Between PARKA Data and RAYMODE X Model Outputs (in dB).**
Source Depth = **500 ft., Receiver Depth = 300 ft.,** Frequency = 50 Hz.
FNOC (i.e., FACT's Internal) Type 3 Bottom on Loss Used in RAYMODE X Model Runs.

	1st Bottom Bounce Region 0-54 km		1st Convergence Zone 54-65 km		2nd Bottom Bounce Region 65-113.5 km		2nd Convergence Zone 113.5-120.5 km		3rd Bottom Bounce Region 120.5-167.5 km		3rd Convergence Zone 167.5-179 km		4th Bottom Bounce Region 179-200 km	
Model Output	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
RAYMODE Coherent	-2.0	5.9	-3.5	3.7	2.5	5.7	-3.6	2.8	7.9	5.3	-9.8	3.6	5.7	5.1
RAYMODE Incoherent	2.8	2.3	-1.0	2.9	4.9	3.0	-3.0	3.6	8.5	4.5	-6.1	2.7	9.1	4.2

CONFIDENTIAL

(C) Table IIIC-8. Means (μ) and Standard Deviations (σ) of Differences Between PARKA Experimental Data and RAYMODE X Model Outputs (in dB).
Source Depth = 500 ft., Receiver Depth = 300 ft., Frequency = 400 Hz.
FNOC (i.e., FACT's Internal) Type 3 Bottom Loss Used in RAYMODE X Model Runs.

	1st Bottom Bounce Region 0-54 km		1st Convergence Zone 54-59.5 km		2nd Bottom Bounce Region 59.5-107 km		2nd Convergence Zone 107-127.5 km		127.5-200 km	
Model Output	μ	σ	μ	σ	μ	σ	μ	σ	μ	σ
RAYMODE Coherent	0.5	1.8	1.6	3.1	-0.1	5.0	-2.4	4.9	1.5	7.3
RAYMODE Incoherent	1.9	1.3	2.5	2.1	3.1	2.7	-0.7	4.0	2.8	7.4

CONFIDENTIAL

(C) Table IIIC-9a. Detection Ranges[1a,b] (km) as a Function of Figure of Merit (FOM) for PARKA Experimental Data and RAYMODE X Predictions. MGS (i.e., RAYMODE's Internal) Type 6 Bottom Loss Used in RAYMODE Model Runs. Source Depth = 500 ft., Receiver Depth = 300 ft., Frequency = 50 Hz.

Data Set	FOM (dB)	R_c[3]		First Convergence Zone: First Lobe Start	First Convergence Zone: First Lobe End	First Convergence Zone: Second Lobe Start	First Convergence Zone: Second Lobe End	
PARKA	80			58	59	60.5	62.5	
RAYMODE Coherent[2]	80	5	Coverage at 6, 15, 57.5 and 62.5 km 100% coverage 8-10 km					
RAYMODE Incoherent	80							
PARKA	85		ZDC[4] 60% 11-23 km	55	59	59.5	64.5	
RAYMODE Coherent	85	10.5	ZDC 45% 12.5-42 km	57	60.5	61.5	64.5	
RAYMODE Incoherent	85	31		58			65	
PARKA	90	36.5	100% coverage 40-46.5 km	53.5				100% coverage 53.5-71.5 km
RAYMODE Coherent	90	11	ZDC 70% 12.5-45 km	55.5			64.5	ZDC 65% 65.5-83 km
RAYMODE Incoherent	90	68						100% coverage to 68 km; ZDC 30%, 109-118 km
PARKA	95	74.5						
RAYMODE Coherent	95	17	ZDC 65% 18-51 km	55			65	ZDC 90% 102-118 km; 100% coverage 65.5-87.5 km
RAYMODE Incoherent	95	130.5						
PARKA	100	125						
RAYMODE Coherent	100	17	ZDC 90% 17.5-27.5 km; ZDC 80%, 46.5-52.5 km; 100% coverage 28.5-45 km	53.5			67.5	ZDC 50% 98-103 km; 100% coverage 68-87.5 km and 104-118.5 km
RAYMODE Incoherent	100	>200						
PARKA	105	149						
RAYMODE Coherent	105	90	100% coverage to 90 km except losses at 23, 27.5-28.5 and 87 km					100% coverage, 100-129 km; ZDC 40% 93-100 km
RAYMODE Incoherent	105	>200						
PARKA	110	>200						
RAYMODE Coherent	110	94.5	100% coverage to 200 km except 94.5-95.5, 99, 132, 167 km					
RAYMODE Incoherent	110	>200						

1a. All detection ranges in kilometers.

1b. Range accuracy is ± 0.25 km.

2. RAYMODE X Coherent results have been smoothed by a 2 km running average.

3. R_c = Range to which coverage is continuous.

4. ZDC = Zonal Detection Coverage (percent the FOM has a greater value than the propagation loss over the indicated interval).

CONFIDENTIAL

(C) Table IIIC-9b. Detection Ranges[1a,b] (km) as a Function of Figure of Merit (FOM) for PARKA Experimental Data and RAYMODE X Predictions. MGS (i.e., RAYMODE'S Internal) Type 6 Bottom Loss Used in RAYMODE X Model Runs.
Source Depth = 500 ft., Receiver Depth = 300 ft., Frequency = 50 Hz

Data Set	FOM (dB)	Second Convergence Zone					Third Convergence Zone			
		First Lobe		Second Lobe			First Lobe		Second Lobe	
		Start	End	Start	End		Start	End	Start	End
PARKA	80									
RAYMODE Coherent[2]	80									
RAYMODE Incoherent	80									
PARKA	85	115.5	117.5				171	171	173	174.5
RAYMODE Coherent	85	120.5	121	123.5	126					
RAYMODE Incoherent	85	121			125					
PARKA	90	114			120.5		169.5			179
RAYMODE Coherent	90	119	124	124.5	126		184			188
RAYMODE Incoherent	90	117.5			127		180.5			188.5
PARKA	95	110			123.5	100% coverage 162-167.5 km				180
RAYMODE Coherent	95	119			126.5	ZDC 40% 127-148.5 km; 100% coverage 177-178 km; 190-191 km	178.5			188.5
RAYMODE Incoherent	95				130.5	100% coverage 131-132.5 km and 190-191 km	164			189
PARKA	100				125	100% coverage resumes at 158 km				181.5
RAYMODE Coherent	100	119			127.5	ZDC 55% 128-140.5 km; 100% coverage 141-165.5 km; (ZDC 60% 166-175 km)				188.5
RAYMODE Incoherent	100									
PARKA	105					No coverage 149-155 km; 100% coverage 155 - >200 km				
RAYMODE Coherent	105					100% coverage 129-168 km; (ZDC 80% 168.5-172.5 km)	173			189
RAYMODE Incoherent	105	>200								

1a. All detection range in kilometers.

1b. Range accuracy is ±0.25 km.

2. RAYMODE X coherent results have been smoothed by a 2 km running average.

4. ZDC = Zonal Detection Coverage (percent the FOM has a greater value the propagation loss over the indicated interval).

CONFIDENTIAL

(C) Table IIIC-10a. Detection Ranges[1a,b] (km) as a Function of Figure of Merit (FOM) for PARKA Experimental Data and RAYMODE X Predictions. MGS (i.e., RAYMODE's Internal) Type 6 Bottom Loss Used in RAYMODE Model Runs. Source Depth = 500 ft., Receiver Depth = 300 ft., Frequency = 400 Hz.

Data Set	FOM (dB)	R_c[3]		First Convergence Zone: First Lobe Start	First Lobe End	Second Lobe Start	Second Lobe End	
PARKA	80							
RAYMODE Coherent[2]	80	4.5	Loss of coverage at 61 km	60	62	63	63.5	
RAYMODE Incoherent	80	4.5		61			61.5	
PARKA	85	9.0		58			59.5	
RAYMODE Coherent	85	6	Coverage at 7.5 km loss of coverage at 57-57.5 km	56	62	62.5	63.5	100% coverage 121.5-122, 122.5-123.5, 124-125 km
RAYMODE Incoherent	85	6		56.5	63	63.4	64	
PARKA	90	36.5		55.5			59	
RAYMODE Coherent	90	7.5	ZDC[4] 80% 8-16.5 km coverage at 64.5-65 km	56			64	ZDC 85% 11[illegible] 5-127/5 km (i.e. discontinuous [illegible] 2nd CZ)
RAYMODE Incoherent	90	8		55.5			64	Coverage at 65 km
PARKA	95	50		54			66	
RAYMODE Coherent	95	9.5	ZDC 35% 10-50 km	52.5			66	Coverage at 128 km
RAYMODE Incoherent	95	26		55			67	
PARKA	100	69					69	ZDC 15% 69-108 km
RAYMODE Coherent	100	17.5	ZDC 75% 18-50 km ZDC 95% 67.5-71 km	52			67	ZDC 55% 128-[illegible]32 km
RAYMODE Incoherent	100	70					70	
PARKA	105	129						
RAYMODE Coherent	105	30	100% coverage to 51.5 km except 44, 48.5, 50, 51 km	51.5			70.5	
RAYMODE Incoherent	105	73.5	Coverage at 174 and 175.5 km					
PARKA	110	188						
RAYMODE Coherent	110	73	ZDC 45% 74-107 km					100% coverage 73.5-77.5 km; ZDC 40% 78.5-103.5 km
RAYMODE Incoherent	110	79						Coverage 103-104, 105-107 km
PARKA	115	>200						
RAYMODE Coherent	115	73	ZDC 80% 73.5-104.5 km					
RAYMODE Incoherent	115	140.5	ZDC 35% 141-160 km					
PARKA	120	>200						
RAYMODE Coherent	120	73.5	100% coverage 74-144 km except 78, 86.5, 135, 136 km					100% coverage [illegible]44-150 and 151-160.5 km
RAYMODE Incoherent	120	>200						
PARKA	125	>200						
RAYMODE Coherent	125	144.5	100% coverage >200 km except 150-151 and 178 km					
RAYMODE Incoherent	125	>200						

1a. All detection ranges in kilometers.

1b. Range accuracy is ± 0.25 km.

2. RAYMODE X Coherent results have been smoothed by a 2 km running average.

3. R_c = Range to which coverage is continuous.

4. ZDC = Zonal Detection Coverage (percent of FOM that has a greater value than the propagation loss over the indicated interval).

CONFIDENTIAL

(C) Table IIIC-10b. Detection Ranges [1a,b] (km) as a Function of Figure of Merit (FOM) for PARKA Experimental Data and RAYMODE X Predictions. MGS (i.e., RAYMODE's Internal) Type 6 Bottom Loss used in RAYMODE X Model Runs.
Source Depth = 500 ft., Receiver Depth = 300 ft., Frequency = 400 Hz.

Data Set	FOM (dB)	Second Convergence Zone First Lobe Start	Second Convergence Zone First Lobe End	Second Convergence Zone Second Lobe Start	Second Convergence Zone Second Lobe End		Third Convergence Zone First Lobe Start	Third Convergence Zone First Lobe End	Third Convergence Zone Second Lobe Start	Third Convergence Zone Second Lobe End
PARKA	80									
RAYMODE Coherent[2]	80									
RAYMODE Incoherent	80									
PARKA	85									
RAYMODE Coherent	85									
RAYMODE Incoherent	85									
PARKA	90	114.5			120.0					
RAYMODE Coherent	90					ZDC[4] 70% 183-188.5 km (i.e., Discontinuous Third CZ)				
RAYMODE Incoherent	90	114	119.5	120.5	126	Coverage across Second CZ except 117.5-118 km and 123.5 km	182.5	184	185	186
PARKA	95	110.5			127.0					
RAYMODE Coherent	95	113	118	118.5	127.5	ZDC 65% in 2nd Lobe of Third CZ 180-191 km	152	154.5		
RAYMODE Incoherent	95	113	119.5	120	127.5		172	176.5	180	190
PARKA	100	108.0			128.0	3 km coverage at 165 km				
RAYMODE Coherent	100	112			127.5	No coverage at 186, 188 km coverage at 192 km	170.5	177	179.5	186
RAYMODE Incoherent	100	112.5			129.5	Coverage at 130, 131.5, 192 km No coverage at 181 km	171.5	177.5	179	191
PARKA	105				129	ZDC 80% 129-183 km No coverage past 183 km				
RAYMODE Coherent	105	110			130.5	ZDC 40% 131-137 km; ZDC 70% 191.5-195 km; no coverage 186 km	169	177	179.5	191
RAYMODE Incoherent	105	110			133	ZDC 80% 191.5-196 km	169			191
PARKA	110									
RAYMODE Coherent	110	107.5			130.5	ZDC 60% 131-140.5 km; Coverage at 159, 164-165, 195.5, 196.5 km	167	177.5	178.5	194
RAYMODE Inocherent	110	107.5			135.5	100% coverage 136.5-139 km and 166-168 km; coverage at 199 km	168			197
PARKA	115									
RAYMODE Coherent	115	104			134.5	ZDC 50% 135-160 km No coverage at 194.5 km	161	177.5	178	>200
RAYMODE Incoherent	115						161			>200
PARKA	120									
RAYMODE Coherent	120						161	178	178.5	>200
RAYMODE Incoherent	120									
PARKA										
RAYMODE Coherent										
RAYMODE Incoherent										

1a. All detection ranges in kilometers.

1b. Range accuracy is ±0.25 km.

2. RAYMODE X coherent results have been smoothed by a 2 km running average.

4. ZDC = Zonal Detection Coverage (percent of the FOM that has a greater value than the propagation loss over the indicated interval).

(C) Table IIIC-11a. Detection Ranges[1a,b] (km) as a Function of Figure of Merit (FOM) for PARKA Experimental Data and RAYMODE X Predictions.
FNOC (i.e., FACT's Internal) Type 3 Bottom Loss Used in RAYMODE Model Runs.
Source Depth = 500 ft., Receiver Depth = 300 ft., Frequency = 50 Hz.

Data Set	FOM (dB)	R_c[3]		First Convergence Zone: First Lobe Start	First Lobe End	Second Lobe Start	Second Lobe End	
PARKA	80			58.0	59.0	60.5	62.5	
RAYMODE Coherent[2]	80	5	No coverage except 9, 10, 21.5 km and interval 36.5-38.5 km			62.5	63.5	
RAYMODE Incoherent	80	4.5						
PARKA	85	11.0	ZDC[4] 60% 11-23 km	55.0	59.0	59.5	64.5	
RAYMODE Coherent	85	10.5	ZDC[4] 45% 12.5-42 km coverage at 72 and 76 km	57	60.5	61.5	64	No coverage except at 119.5 and 121 km
RAYMODE Incoherent	85	14	100% coverage 25-37 km	58			65	
PARKA	90	36.5	100% coverage 40-46.5 km	53.5				100% coverage, 53.5-71.5 km
RAYMODE Coherent	90	12	ZDC 70% 12.5-44.5 km	55.5			64.5	Coverage at 65.5, 66.5, and 68-80, 80.5-81.5, 82.5, and 83 km
RAYMODE Incoherent	90	69						
PARKA	95	74.5						
RAYMODE Coherent	95	17	ZDC 70% 18-52 km	54.5			65	100% coverage 65.5-87 km except 68 km and 102-127 km except 102.5, 103.5, 117 and 119 km
RAYMODE Incoherent	95	153	100% coverage to 191.5 km except 158-165.5 km					
PARKA	100	135.0						
RAYMODE Coherent	100	17	ZDC 90% 17.5-27 km; ZDC 90% 47.5-52 km; 100% coverage 29-45.5 km	53.5			88	100% coverage 88.5-90.5, 100-103 km coverage at 91.5, 98, 99 km
RAYMODE Incoherent	100	197.5						
PARKA	105	149						
RAYMODE Coherent	105	17	ZDC 85% 17.5-28 km 100% coverage 28.5-46 km	46			88	ZDC 50% 91-100 km
RAYMODE Incoherent	105	>200						
PARKA	110	>200						
RAYMODE Coherent	110	17	100% coverage to 200 km except 17, 18, 23, 28-28.5, 95-98, 132 km					
RAYMODE Incoherent	110	>200						

1a. All detection ranges in kilometers.

1b. Range accuracy is ± 0.25 km.

2. RAYMODE X Coherent results have been smoothed by a 2 km running average.

3. R_c = Range to which coverage is continuous.

4. ZDC = Zonal Detection Coverage (percent the FOM has a greater value than the propagation loss over the indicated interval).

(C) Table IIIC-11b. Detection Ranges[1a,b] (km) as a Function of Figure of Merit (FOM) for PARKA Experimental Data and RAYMODE X Predictions. FNOC (i.e., FACT's Internal) Type 3 Bottom Loss Used in RAYMODE X Model Runs. Source Depth = 500 ft., Receiver Depth = 300 ft., Frequency = 50 Hz.

Data Set	FOM (dB)	Second Convergence Zone First Lobe Start	Second Convergence Zone First Lobe End	Second Convergence Zone Second Lobe Start	Second Convergence Zone Second Lobe End		Third Convergence Zone First Lobe Start	Third Convergence Zone First Lobe End	Third Convergence Zone Second Lobe Start	Third Convergence Zone Second Lobe End
PARKA	80									
RAYMODE Coherent[2]	80									
RAYMODE Incoherent	80									
PARKA	85	115.5	117.5				171.0	[illegible]	173.0	174.5
RAYMODE Coherent	85			124	126					
RAYMODE Incoherent	85	121.5			124.5					
PARKA	90	114.0			120.5		169.5			178.0
RAYMODE Coherent	90			123.5	126.5	ZDC[4] 50% 106-122.5 km			184.5	188
RAYMODE Incoherent	90	117.5			127		180.5			188.5
PARKA	95	110.0			123.5	100% coverage 162-167.5 km				
RAYMODE Coherent	95	119			126.5	ZDC 30% 127-141 km; ZDC 35% 163-179 km; 100% coverage 141-162 km; 189.5-196.5 km	178.5			188.5
RAYMODE Incoherent	95									
PARKA	100	112			125	100% coverage resumes at 158 km				181.5
RAYMODE Coherent	100	119			128	ZDC 60% 128-140.5 km; ZDC 75% 167-176.5 km; 100% coverage 137-164, 189.5-191, 192.5-193.5 km	176.0			188.5
RAYMODE Incoherent	100									
PARKA	105					No coverage, 149-155 km 100% coverage, 155 to >200 km				
RAYMODE Coherent	105	100			129	ZDC 80% 129-132.5 km, ZDC 75% 189-200 km; ZDC 95% 168-172.5 km 100% coverage 132.5-168 km	172.5		189	
RAYMODE Incoherent	105									

1a. All detection range in kilometers.

1b. Range accuracy is ±0.25 km.

2. RAYMODE X coherent results have been smoothed by a 2 km running average.

4. ZDC = Zonal Detection Coverage (percent of the FOM has a greater value than the propagation loss over the indicated interval).

CONFIDENTIAL

(C) Table IIIC-12a. Detection Ranges[1a,b] (km) as a Function of Figure of Merit (FOM) for PARKA Experimental Data and RAYMODE X Predictions. FNOC (i.e., FACT's Internal) Type 3 Bottom Loss Used in RAYMODE Model Runs. Source Depth = 500 ft., Receiver Depth = 300 ft., Frequency = 400 Hz.

Data Set	FOM (dB)	R_c[3]		First Convergency Zone				
				First Lobe		Second Lobe		
				Start	End	Start	End	
PARKA	85	9.0		58.0			59.5	
RAYMODE Coherent[2]	85	6	ZDC[4] 35% 7-20 km coverage at 38.5 km	56	62	63	64	
RAYMODE Incoherent	85	5.5	100% coverage 6-7 km and 63-63.5 km	56			62.5	
PARKA	90	36.5		55.5			59.0	
RAYMODE Coherent	90	7.5	ZDC 60% 8-54 km coverage at 64.5, 66 km	56			64	ZDC 45%. A cross second CZ 114-127.5 km
RAYMODE Incoherent	90	44		55			64	No coverage at 117.5 -118 km
PARKA	95	50.0		54.0			66.0	
RAYMODE Coherent	95	7.5	ZDC 90% 8-50 km	51.5			64	ZDC 15% 69-92 km; 100% coverage 64.5-65, 65.5-66, 106 km
RAYMODE Incoherent	95	68.5	Coverage at 69 km					
PARKA	100	69.0					69.0	ZDC 15% 69-108 km
RAYMODE Coherent	100	48	ZDC 40% 68-111 km No coverage at 48 km	51			66	ZDC 20% 128-138.5 km
RAYMODE Incoherent	100	94						
PARKA	105	120.0						
RAYMODE Coherent	105	50.5	ZDC 70% 67-112 km	51			66	ZDC 25% 130.5-167.5 km
RAYMODE Incoherent	105	136						
PARKA	110	188.0						
RAYMODE Coherent	110	66	ZDC 80% 66.5-108 km					
RAYMODE Incoherent	110	198	100% coverage to 200 km with loss at 198 km					
PARKA	115	>200						
RAYMODE Coherent	115	96	ZDC 80% 97-108 km					
RAYMODE Incoherent	115	>200						
PARKA	120	>200						
RAYMODE Coherent	120	103.5	100% coverage to 200 km except at 103.5, 133, 195, 199 km					
RAYMODE Incoherent	120	>200						

1a. All detection ranges in kilometers.

1b. Range accuracy is ± 0.25 km.

2. RAYMODE X Coherent results have been smoothed by a 2 km running average.

3. R_c = Range to which coverage is continuous.

4. ZDC = Zonal Detection Coverage (percent the FOM has a greater value than the propagation loss over the indicated interval).

CONFIDENTIAL

(C) Table IIIC-12b. Detection Ranges[1a,b] (km) as a Function of Figure of Merit (FOM) for PARKA Experimental Data and RAYMODE X Preditions. FNOC (i.e., FACT's Internal) Type 3 Bottom Loss Used in RAYMODE X Model Runs. Source Depth = 500 ft., Receiver Depth = 300 ft., Frequency = 400 Hz.

Data Set	FOM (dB)	Second Convergence Zone: First Lobe Start	First Lobe End	Second Lobe Start	Second Lobe End		Third Convergence Zone: First Lobe Start	First Lobe End	Second Lobe Start	Second Lobe End
PARKA	85									
RAYMODE Coherent[2]	85	121.5	123	124	124.5	No coverage at 122 km				
RAYMODE Incoherent	85									
PARKA	90	114.5			120.0					
RAYMODE Coherent	90	114			127.5	ZDC[4] 70% across 2nd lobe of third CZ 179.5-190.5 km	172	176		
RAYMODE Incoherent	90	114	119.5	120.5	124.5	Coverage at 180, 187-188 km	182.5	184.5	185	186.5
PARKA	95	110.5			127.0					
RAYMODE Coherent	95	113			127.5	ZDC 75% across 2nd lobe of third CZ 180-190.5 km; No coverage 118, 124 km coverage at 128.5 km	172	175		
RAYMODE Incoherent	95	113.5	119.5	119.5	127.5	No coverage 180.5-181 km 181.5-182 km	172	176.5	178.5	190
PARKA	100	108.0			128.0	3 km coverage at 165 km				
RAYMODE Coherent	100	112.5			120.5	No coverage 186, 187.5 km coverage 192 km	171	177	179	191
RAYMODE Incoherent	100	110.5			130.5	Coverage at 131.5, 192 km No coverage at 181 km	171.5	177.5	179	191
PARKA	105				129.0	ZDC 60% 129-183 km No coverage past 183 km				
RAYMODE Coherent	165	112			130.5	No coverage at 191, 192 km	168.5	177.5	178.5	194
RAYMODE Incoherent	105									
PARKA	110									
RAYMODE Coherent	110	108.5			132	ZDC 65% 132-165 km. 100% coverage 196-198 and 198.5 km	165.5	177.5	178.5	194.5
RAYMODE Incoherent	110									
PARKA	115									
RAYMODE Coherent	115	108			133	ZDC 95% 133.5-163.5 km; 100% coverage 195-198 km and 199.5 km	163	177.5	178	194.5
RAYMODE Incoherent	115									

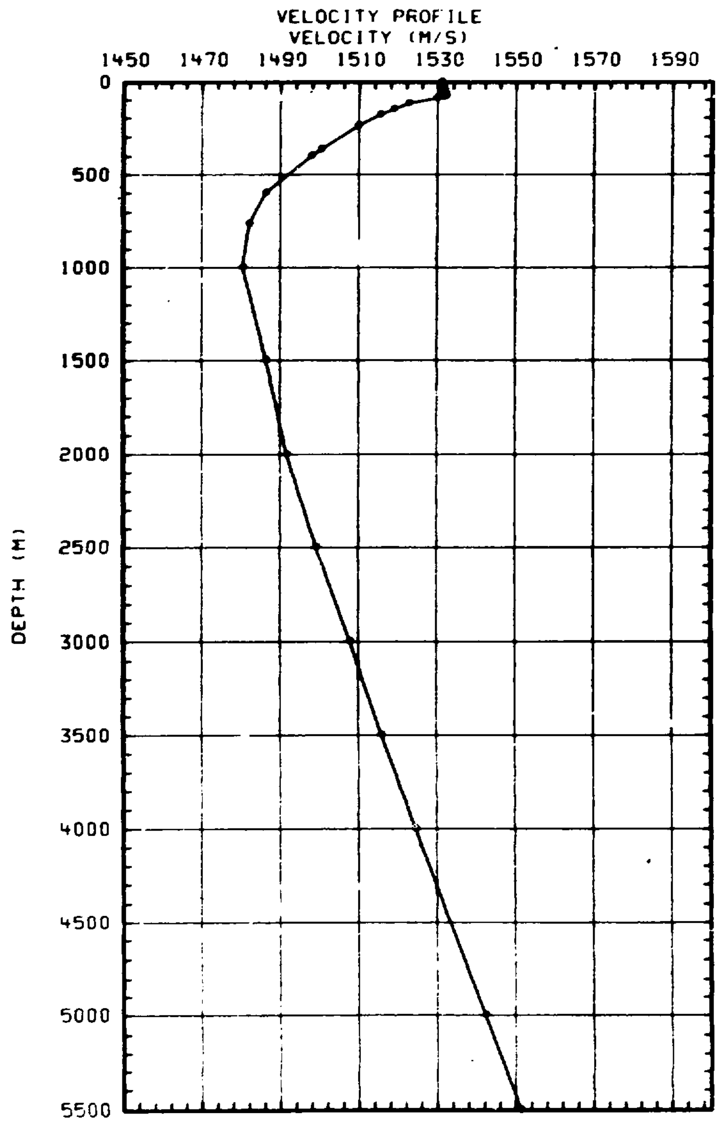
1a. All detection range in kilometers.

1b. Range accuracy is ±0.25 km.

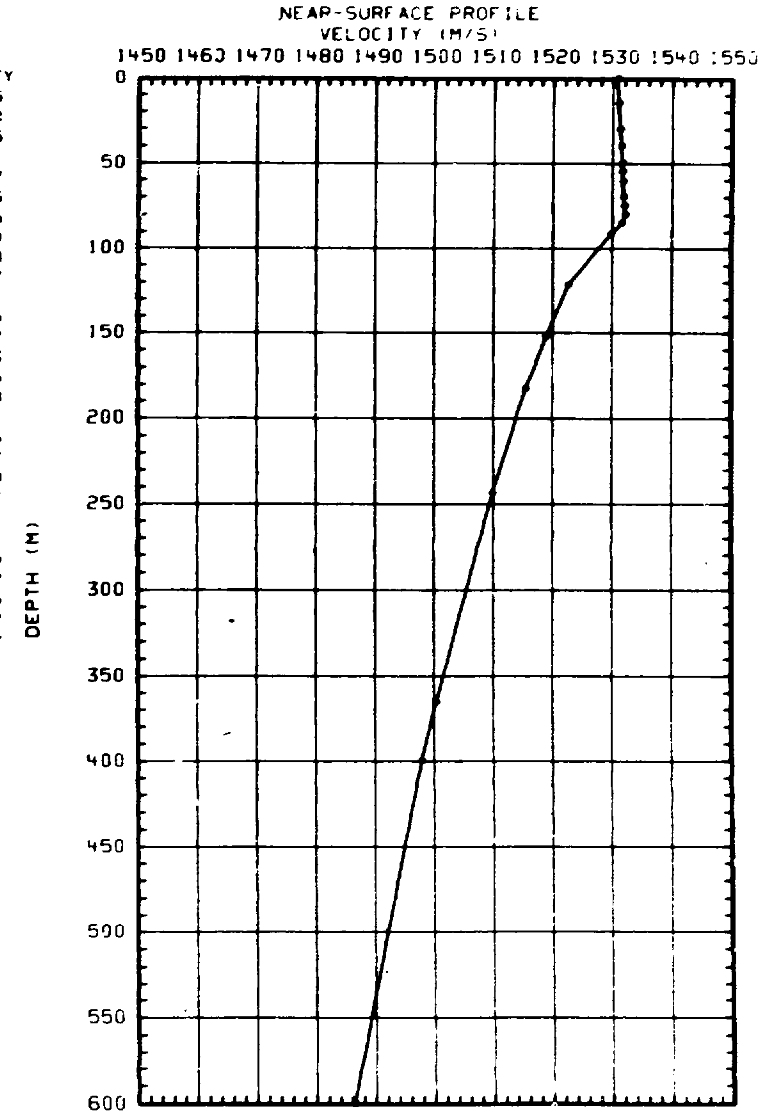
2. RAYMODE X coherent results have been smoothed by a 2 km running average.

4. ZDC = Zonal Detection Coverage (percent the FOM has a greater value than the propagation loss over the indicated interval).

CONFIDENTIAL

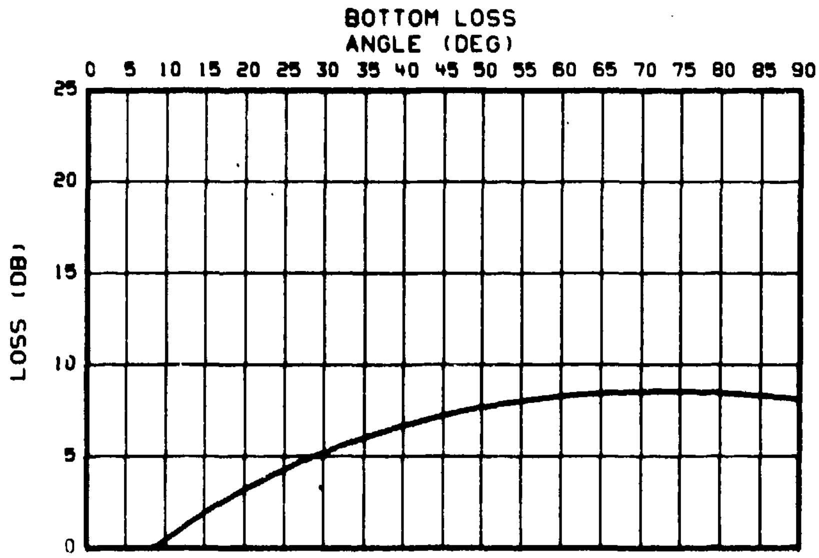


DEPTH	VELOCITY
0.0	1530.75
15.2	1531.00
30.5	1531.25
40.0	1531.41
50.0	1531.57
55.0	1531.66
61.0	1531.75
70.0	1531.90
75.0	1531.98
80.0	1532.07
85.0	153'.41
91.4	1529.75
121.9	1522.52
152.4	1518.83
182.8	1515.35
243.8	1509.78
365.7	1500.30
400.0	1497.76
600.0	1486.27
762.0	1481.89
1000.0	1480.47
1500.0	1486.44
2000.0	1491.74
2500.0	1499.15
3000.0	1507.92
3500.0	1515.95
4000.0	1524.62
5000.0	1542.32
5500.0	1551.31



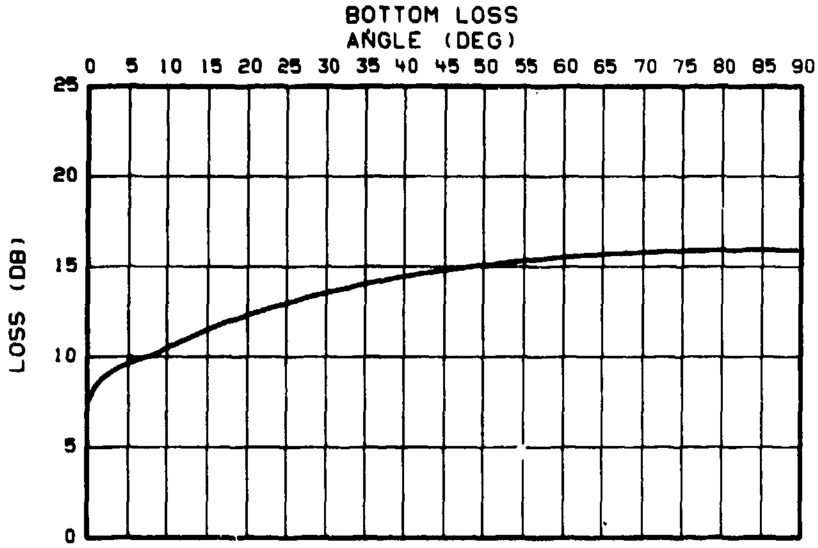
CONFIDENTIAL

(U) Figure IIIC-1. PARKA Sound Speed Profile



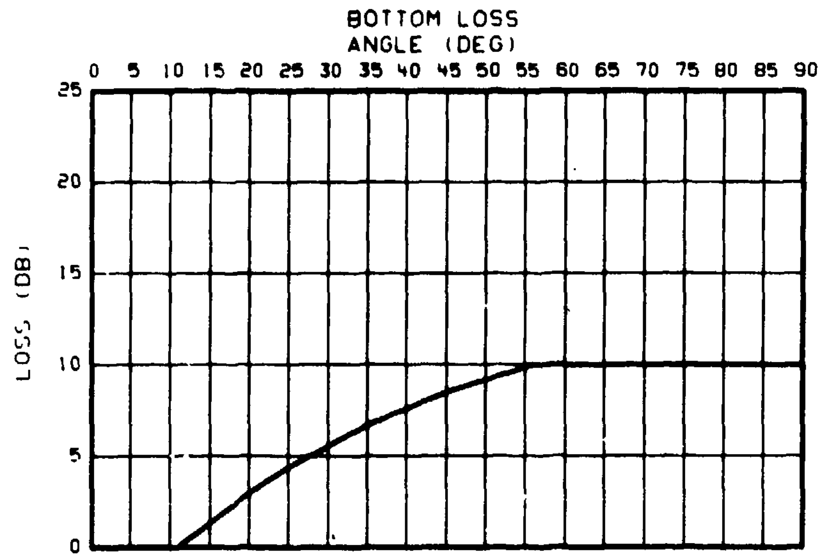
CONFIDENTIAL

(C) Figure IIIC-2. Bottom Loss Versus Grazing Angle. MGS 6. Frequency = 50 Hertz



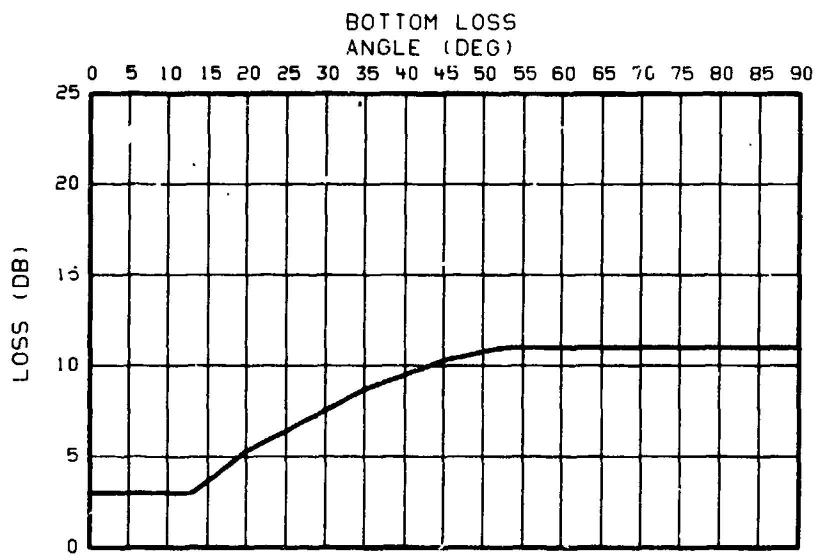
CONFIDENTIAL

(C) Figure IIIC-3. Bottom Loss Versus Grazing Angle. MGS 6. Frequency = 400 Hertz



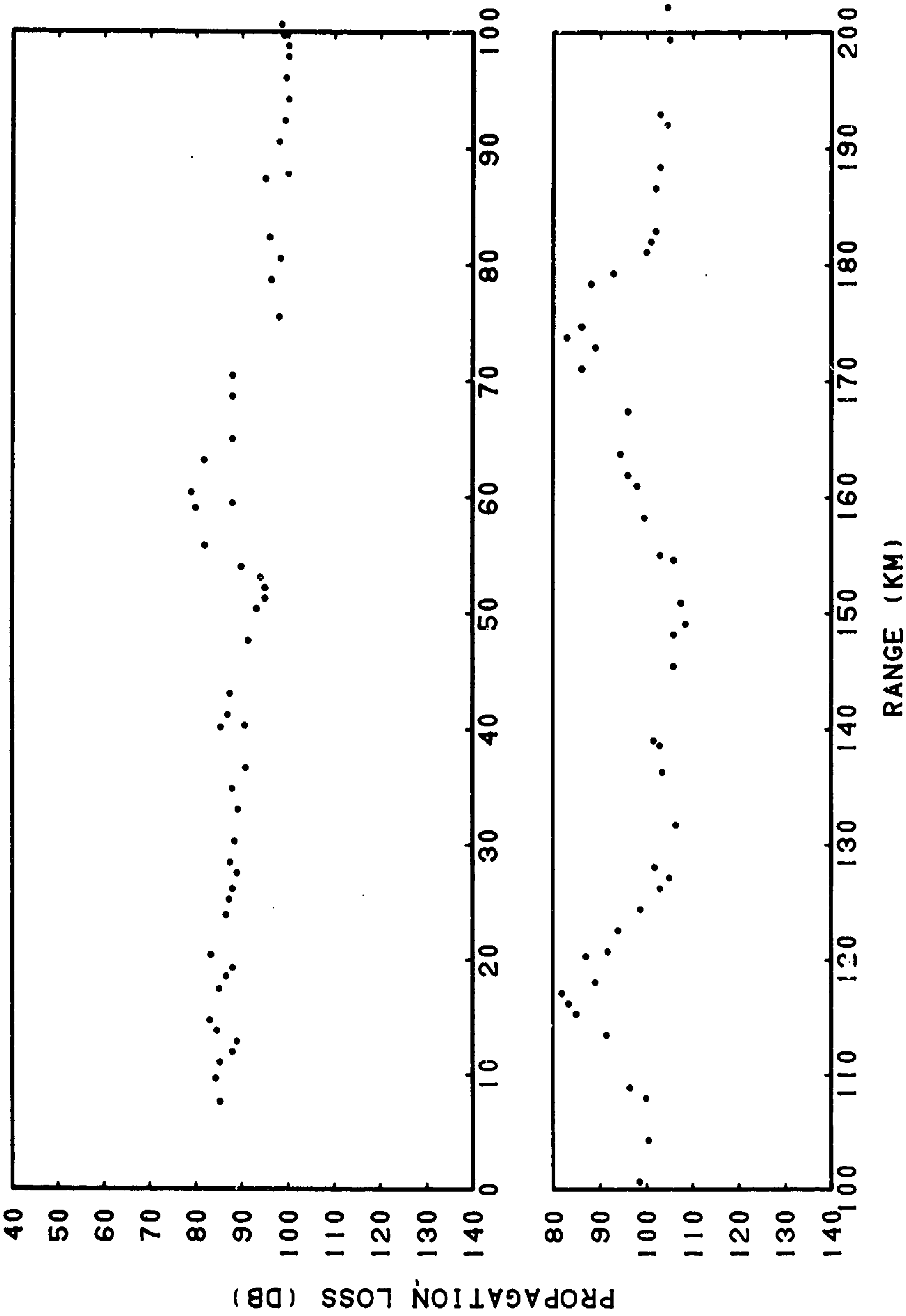
CONFIDENTIAL

(C) Figure IIIC-4. Bottom Loss Versus Grazing Angle. FNOC 3. Frequency = 50 Hertz



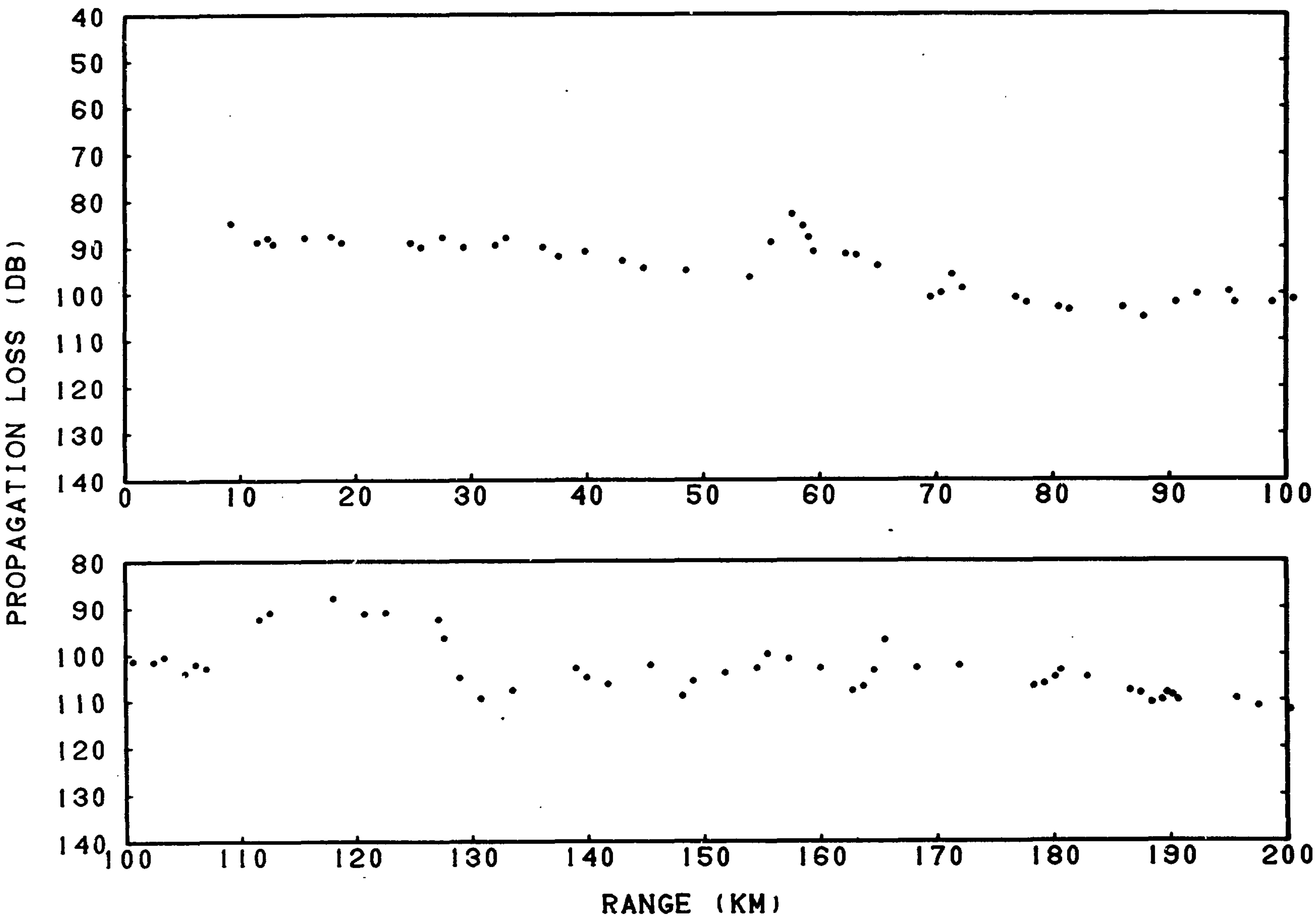
CONFIDENTIAL

(C) Figure IIIC-5. Bottom Loss Versus Grazing Angle. FNOC 3. Frequency = 400 Hertz



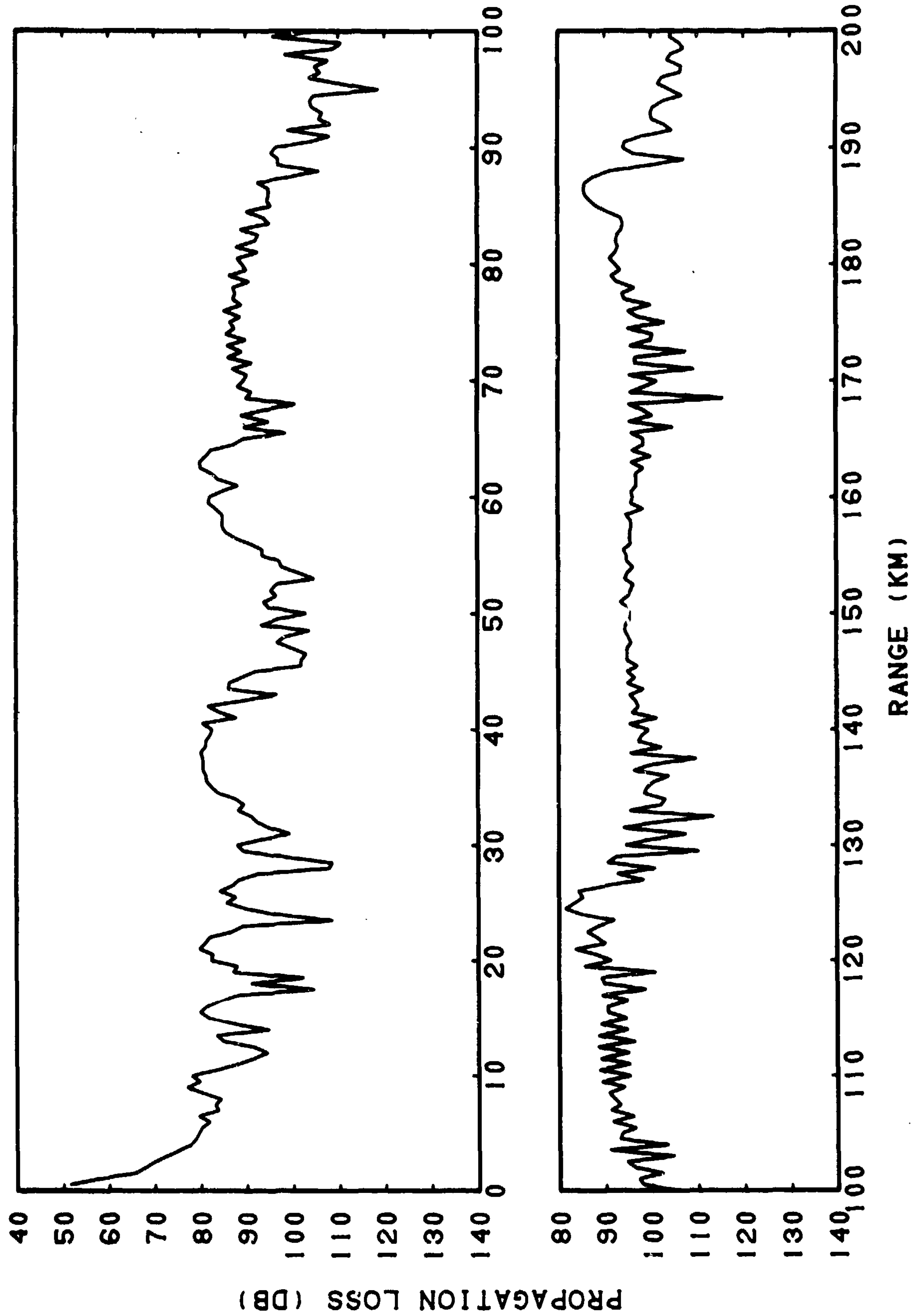
CONFIDENTIAL

(C) Figure IIIC-6. PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 50 Hertz



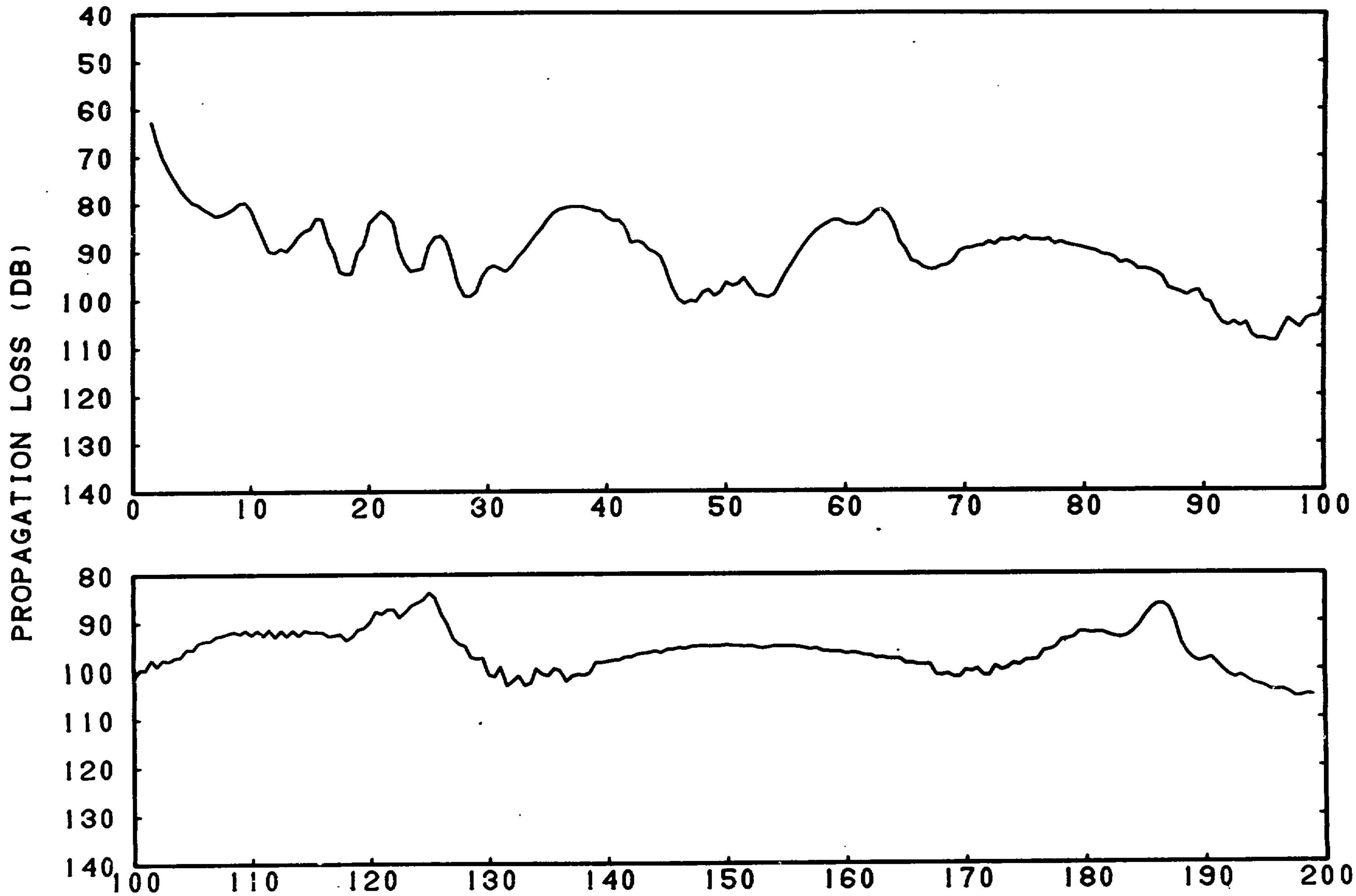
CONFIDENTIAL

(C) Figure IIIC-7. PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 400 Hertz



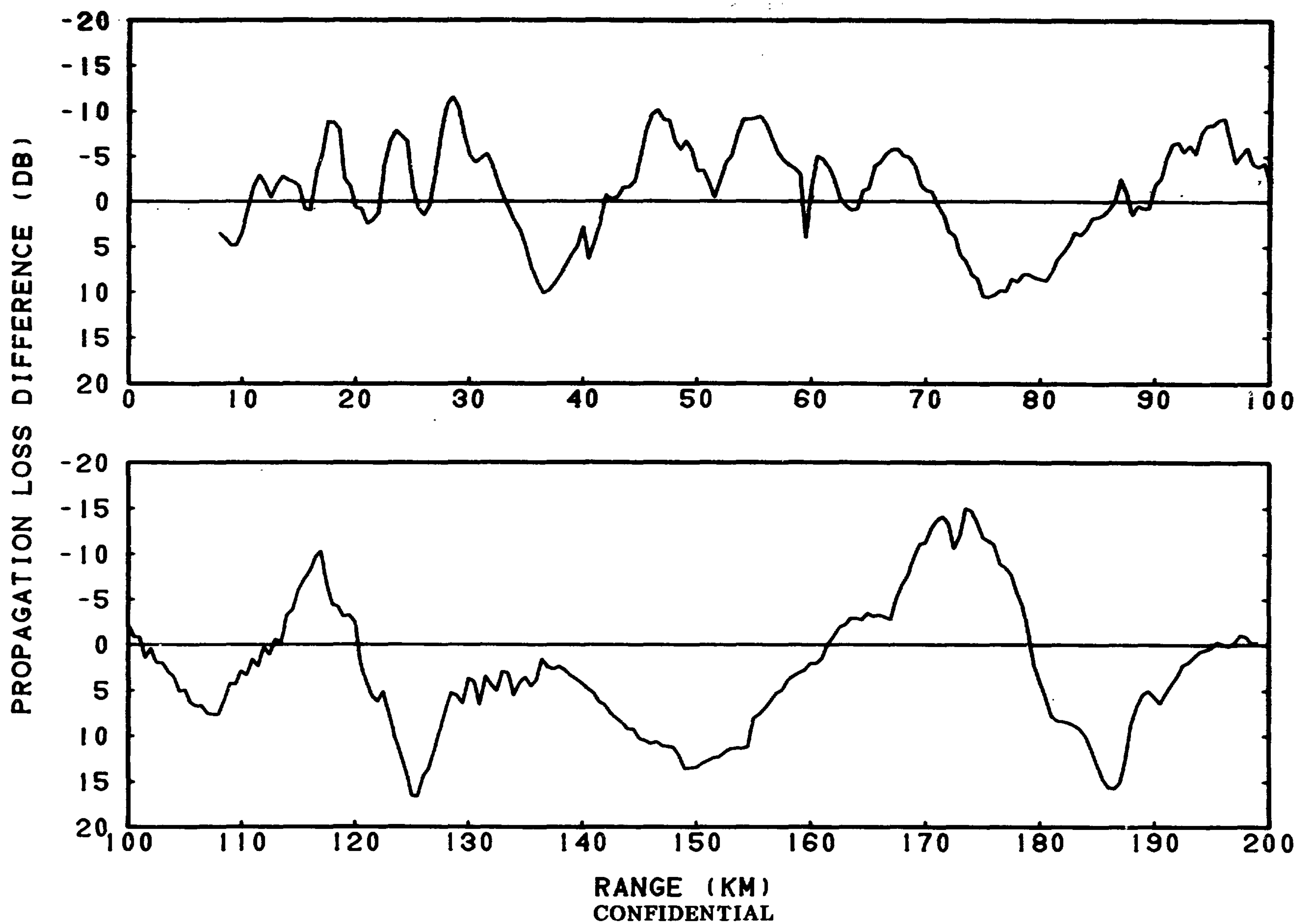
CONFIDENTIAL

(C) Figure IIIC-8. RAYMODE X (Coherent), Bottom Loss = MGS 6, Frequency = 50 Hertz

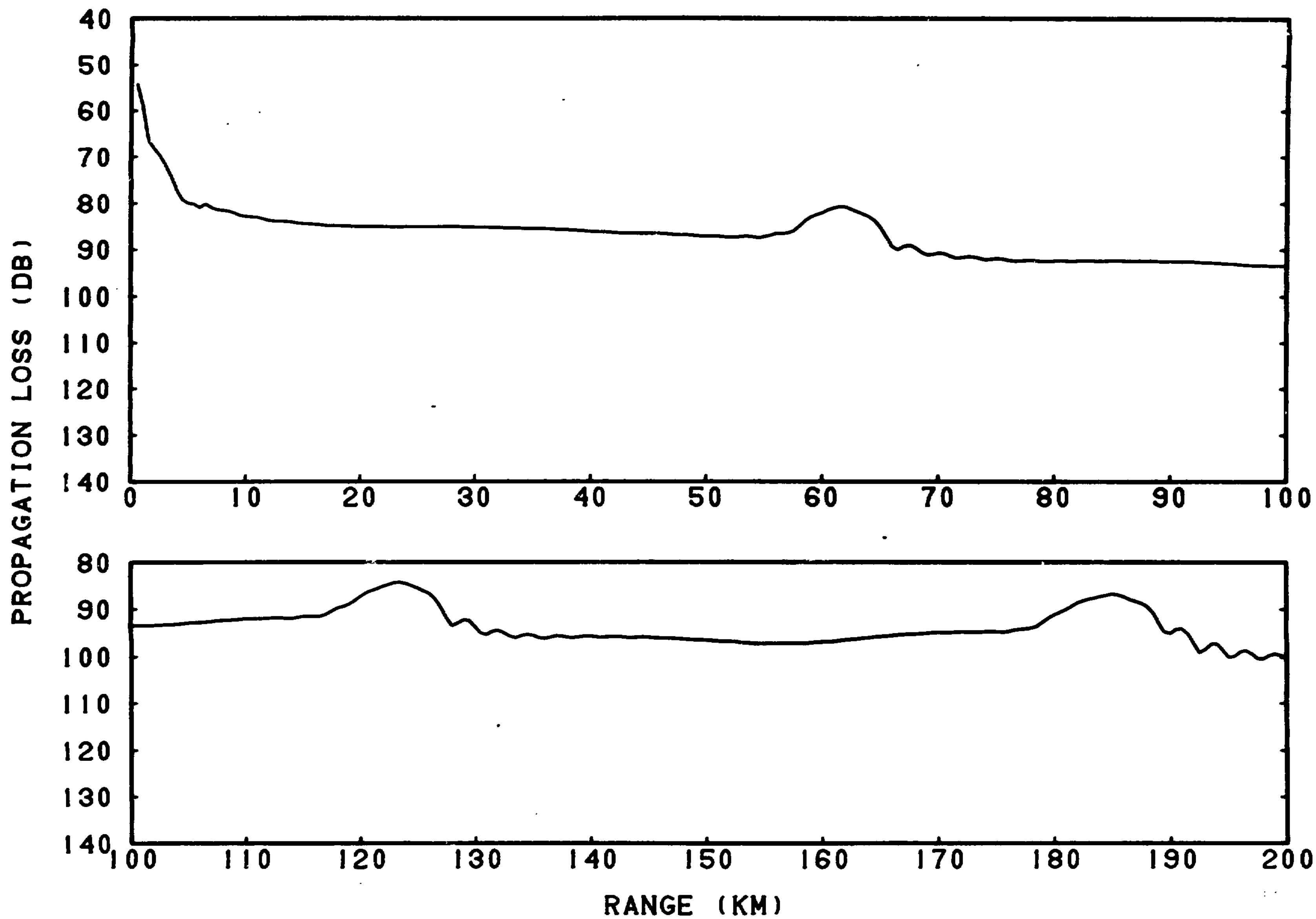


CONFIDENTIAL

(C) Figure IIIC-9. RAYMODE X (Coherent), Bottom Loss = MGS 6, Frequency = 50 Hertz, Sliding Averages of 5 Points (2.00 Kilometers)

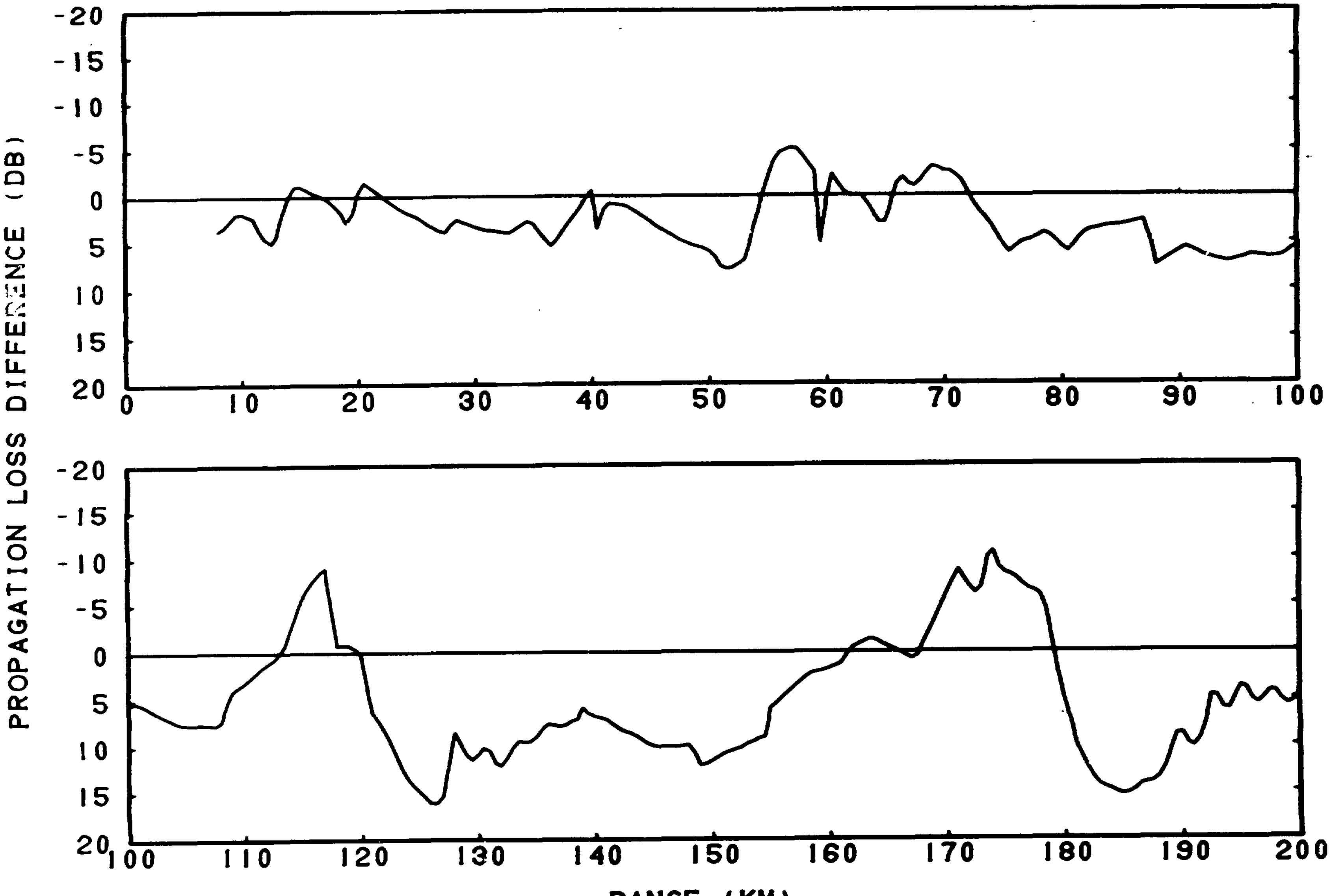


(C) Figure IIIC-10. Smoothed RAYMODE X (Coherent), Bottom Loss = MGS 6, Frequency = 50 Hertz, Subtracted from PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 50 Hertz



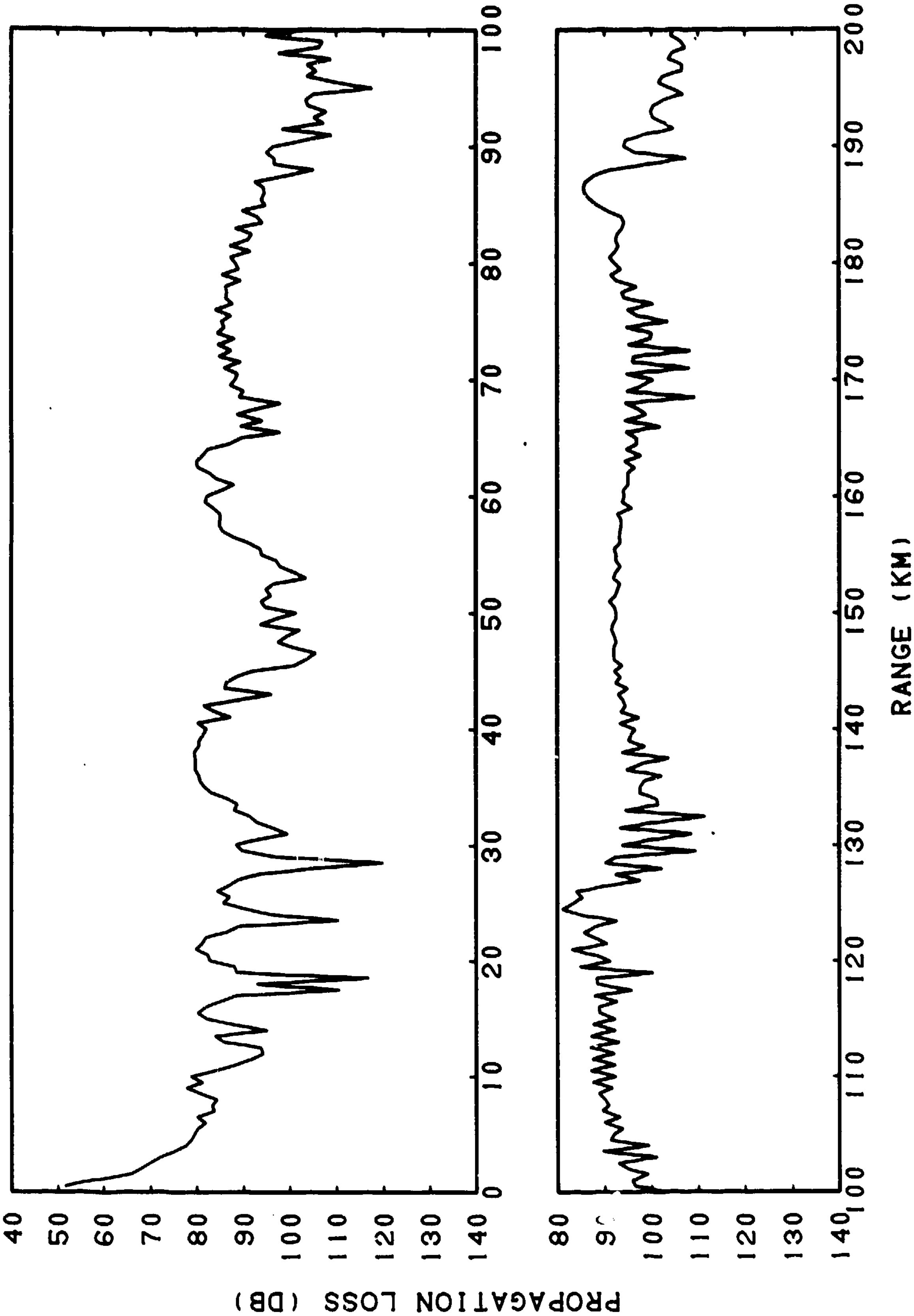
CONFIDENTIAL

(C) Figure IIIC-11. RAYMODE X (Incoherent), Bottom Loss = MGS 6, Frequency = 50 Hertz



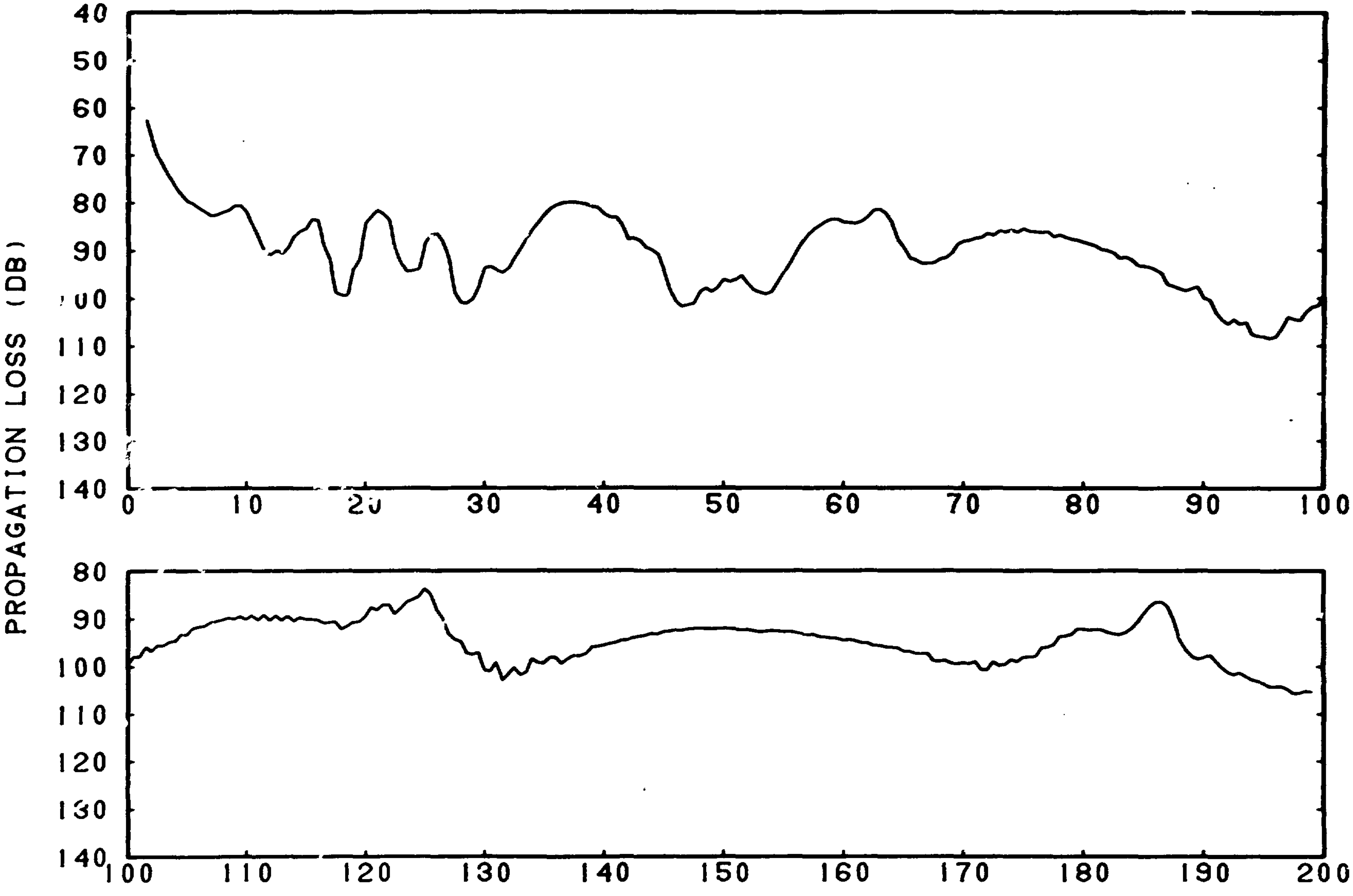
CONFIDENTIAL

(C) Figure IIIC-12. RAYMODE X (Incoherent), Bottom Loss MGS 6, Frequency = 50 Hertz, Subtracted from PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 50 Hertz



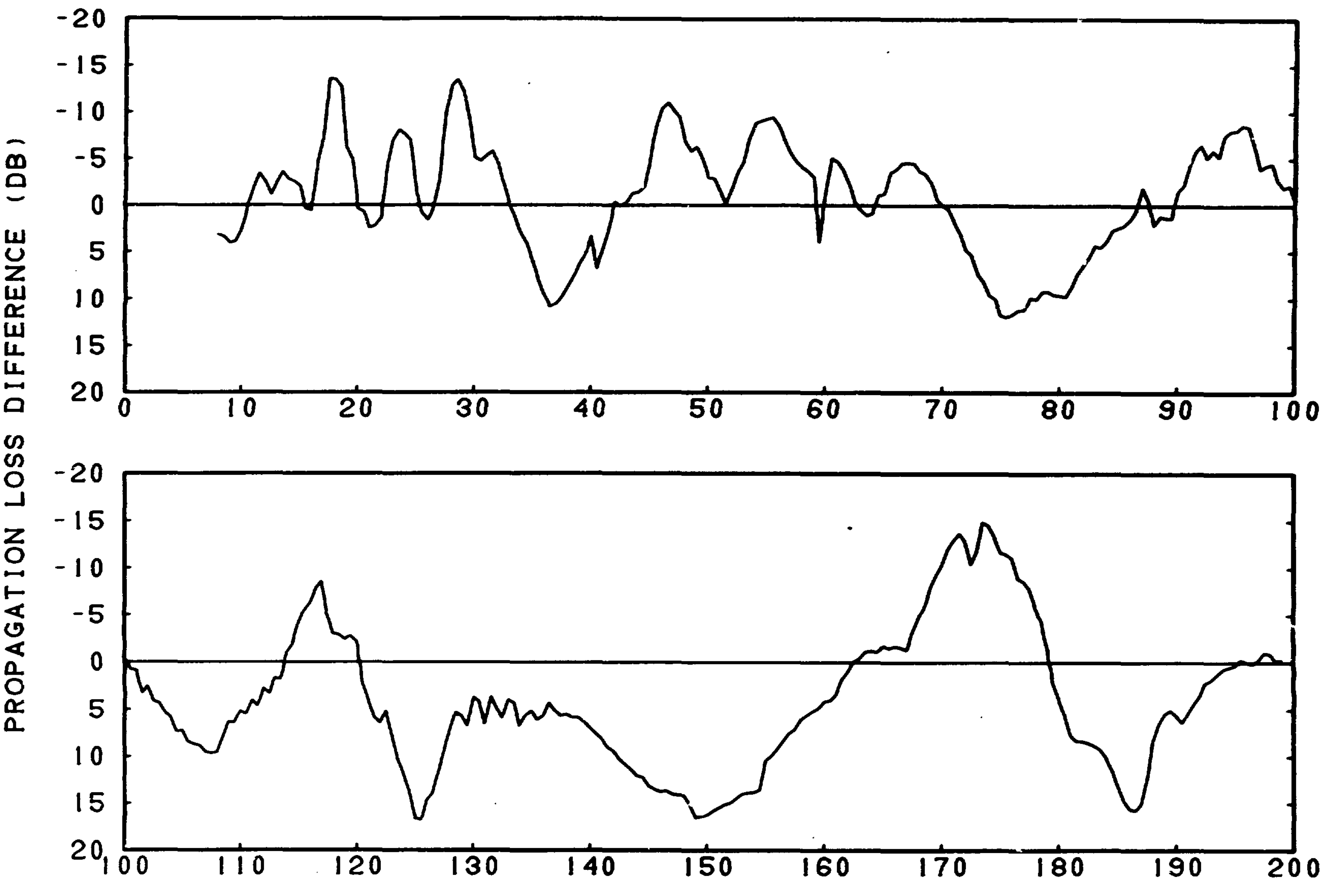
CONFIDENTIAL

(C) Figure IIIC-13. RAYMODE X (Coherent), Bottom Loss = FNOC Type 3, Frequency = 50 Hertz



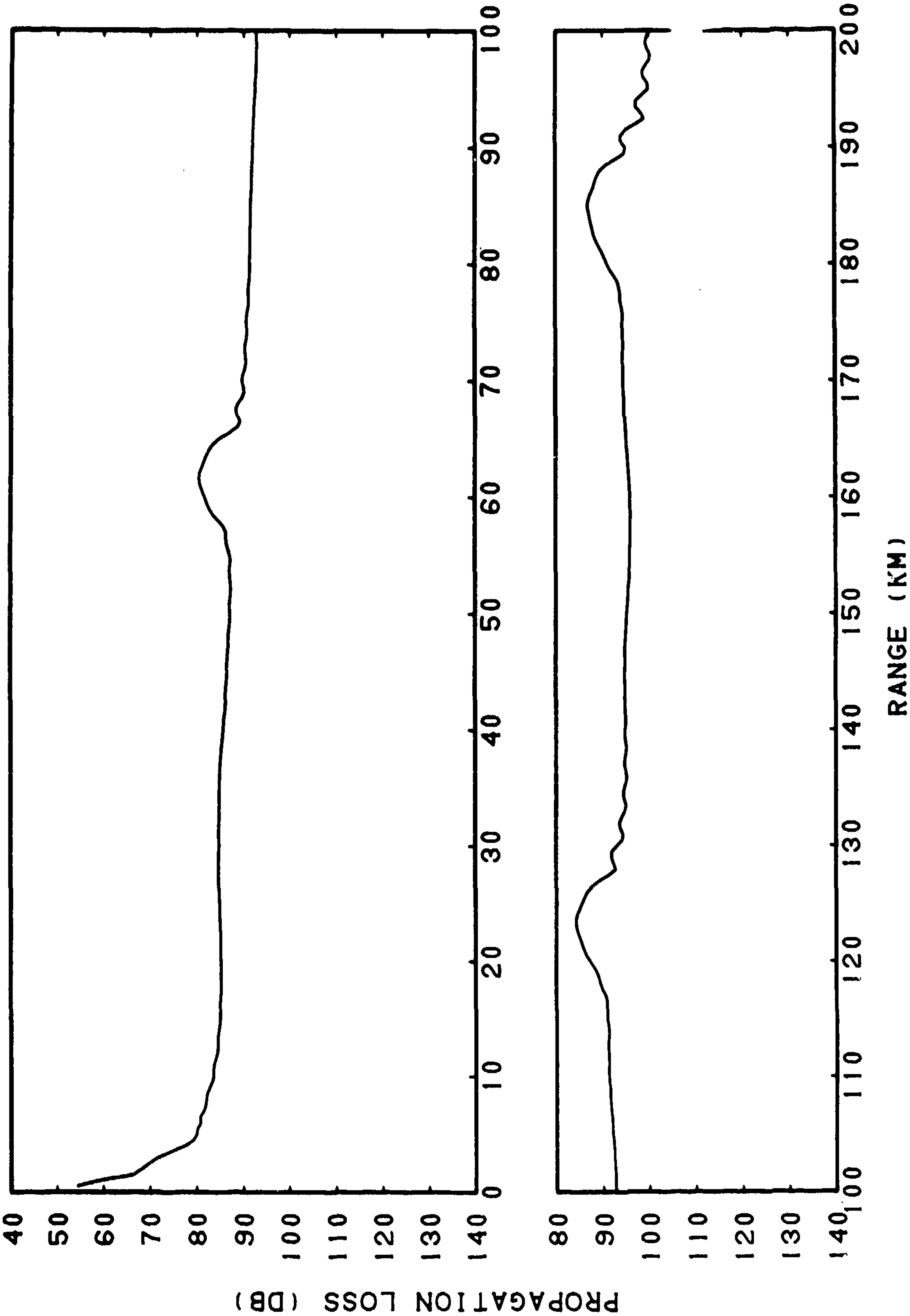
CONFIDENTIAL

(C) Figure IIIC-14. RAYMODE X (Coherent), Bottom Loss = FNOC Type 3, Frequency = 50 Hertz, *Sliding Averages of 5 Points* (2.00 Kilometers)



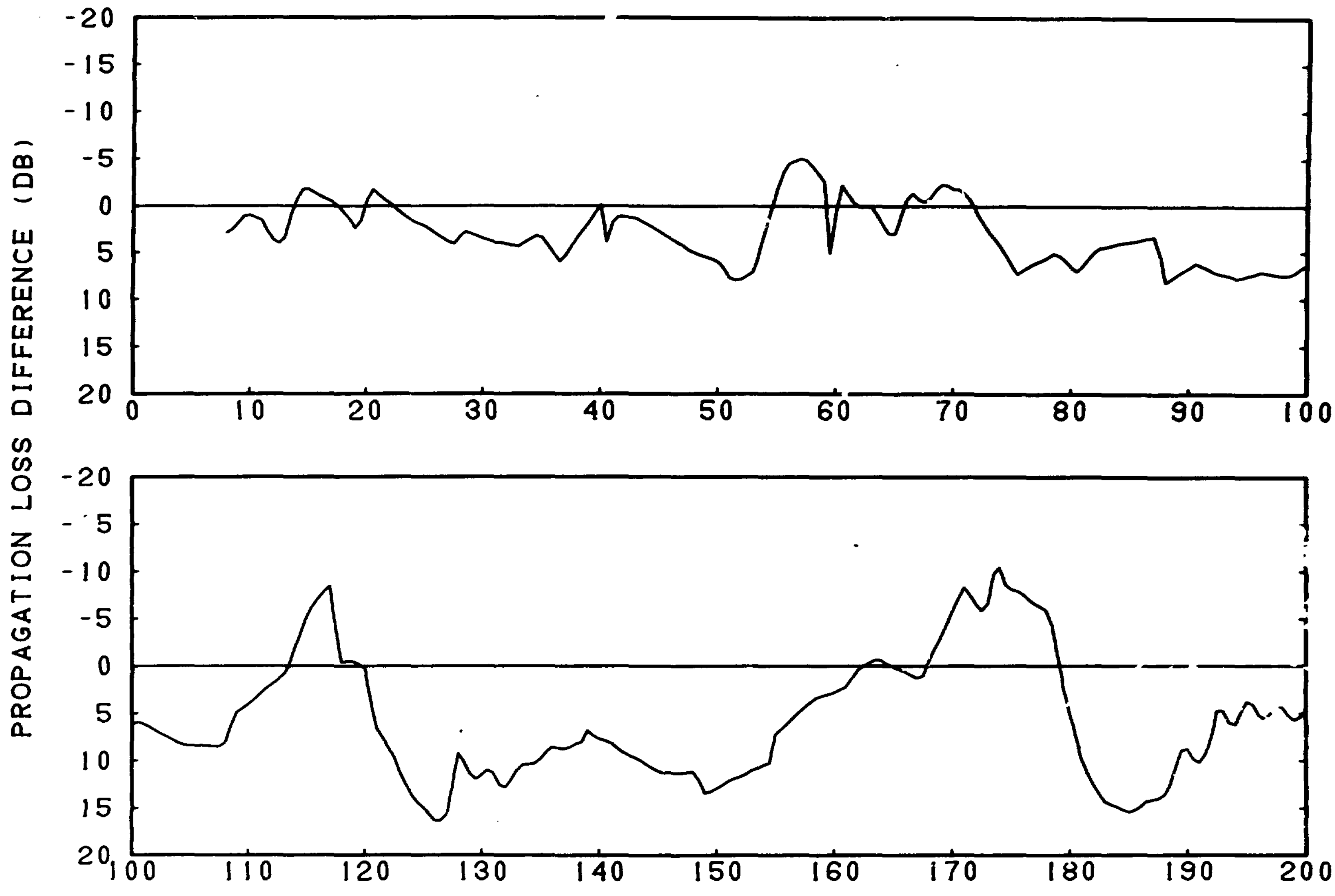
CONFIDENTIAL

(C) Figure IIIC-15. Smoothed RAYMODE X (Coherent), Bottom Loss = FNOC Type 3, Frequency = 50 Hertz, Subtracted from PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 50 Hertz



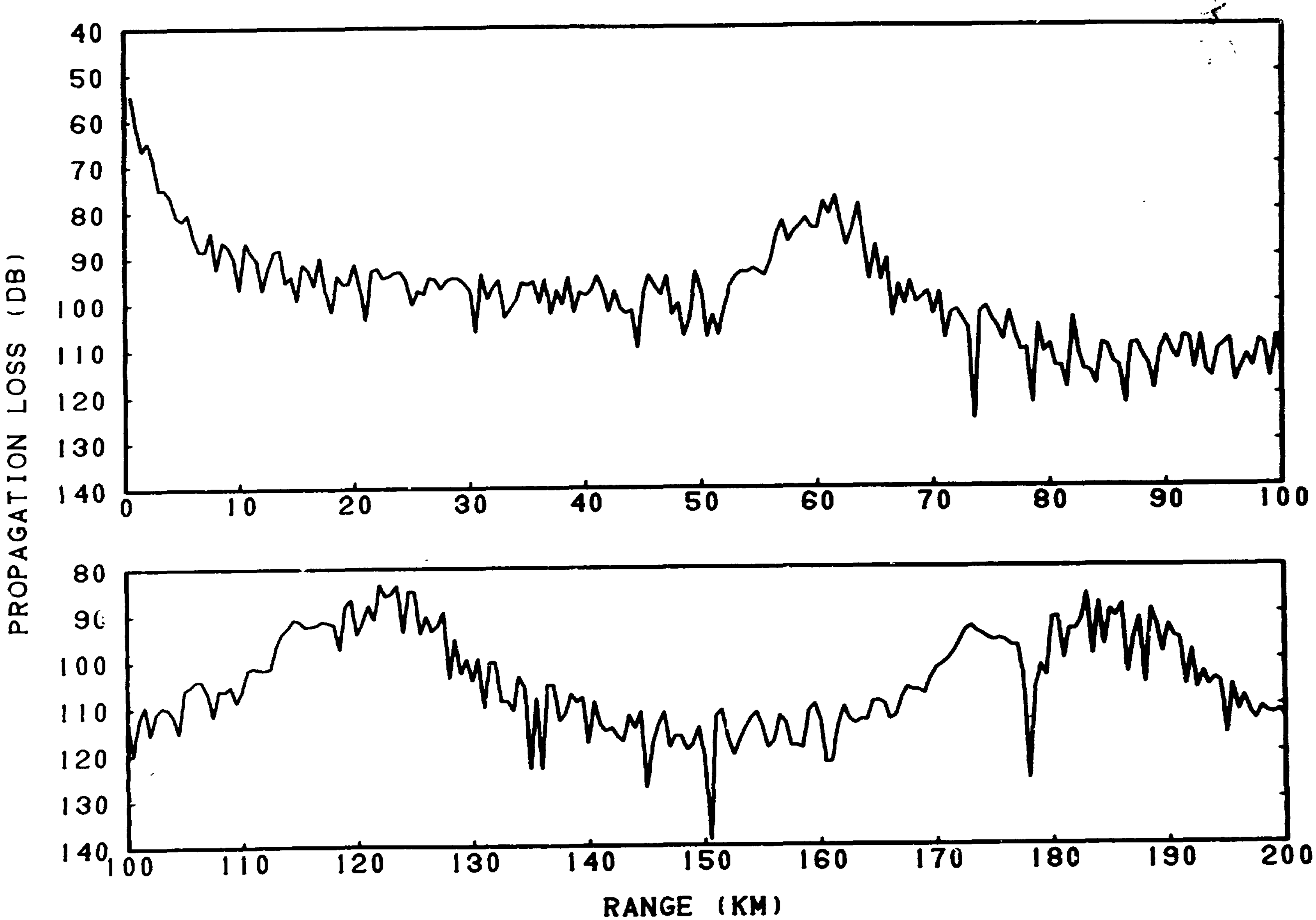
CONFIDENTIAL

(C) Figure IIIC-16. RAYMODE X (Incoherent), Bottom Loss = FNOC Type 3, Frequency = 50 Hertz



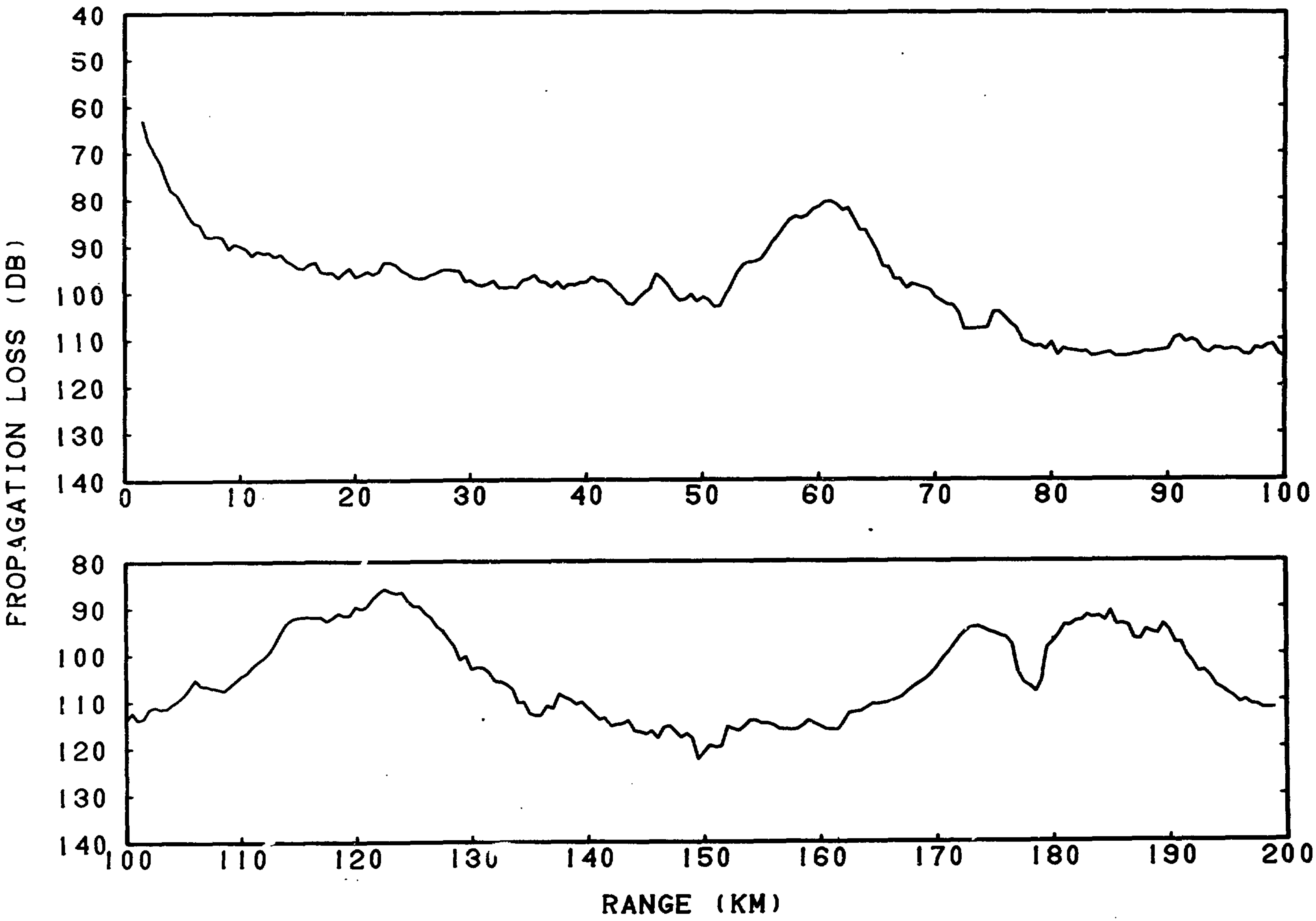
CONFIDENTIAL

(C) Figure IIIC-17. RAYMODE X (Incoherent), Bottom Loss = FNOC Type 3, Frequency = 50 Hertz, Subtracted from PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 50 Hertz



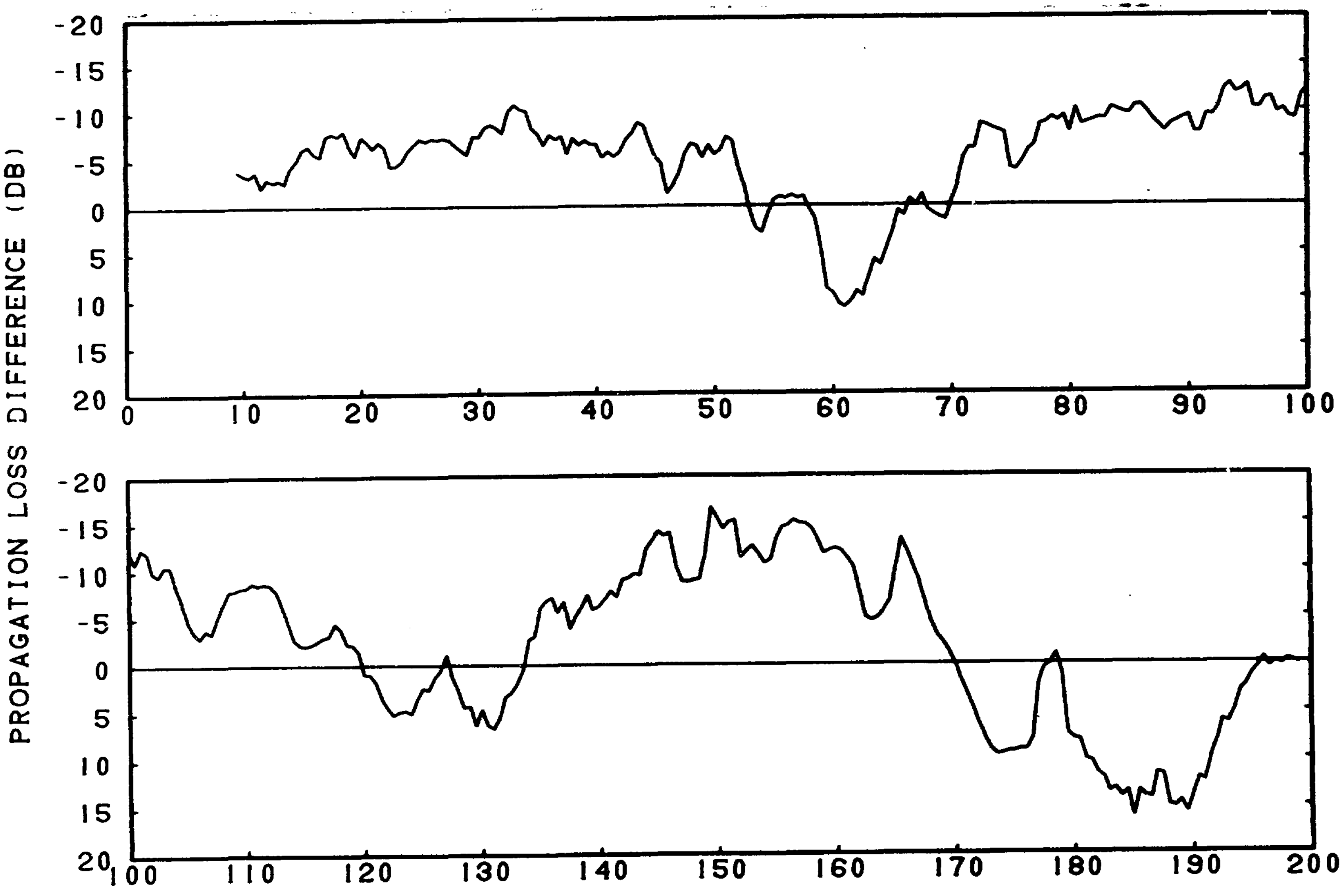
CONFIDENTIAL

(C) Figure IIIC-18. RAYMODE X (Coherent), Bottom Loss = MGS 6, Frequency = 400 Hertz



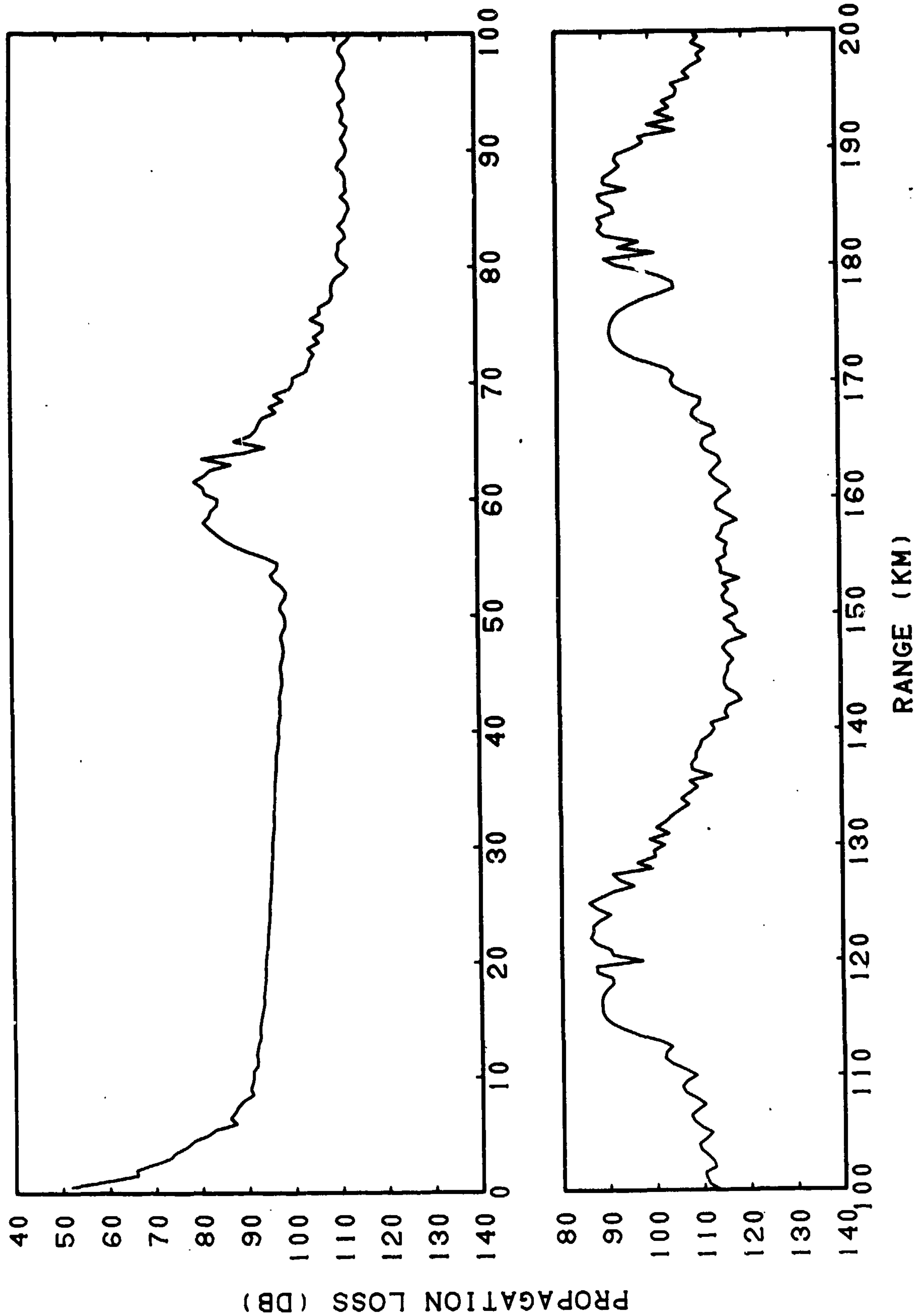
CONFIDENTIAL

(C) Figure IIIC-19. RAYMODE X (Coherent), Bottom Loss = MGS 6, Frequency = 400 Hertz, Sliding Averages of 5 Points (2.00 Kilometers)



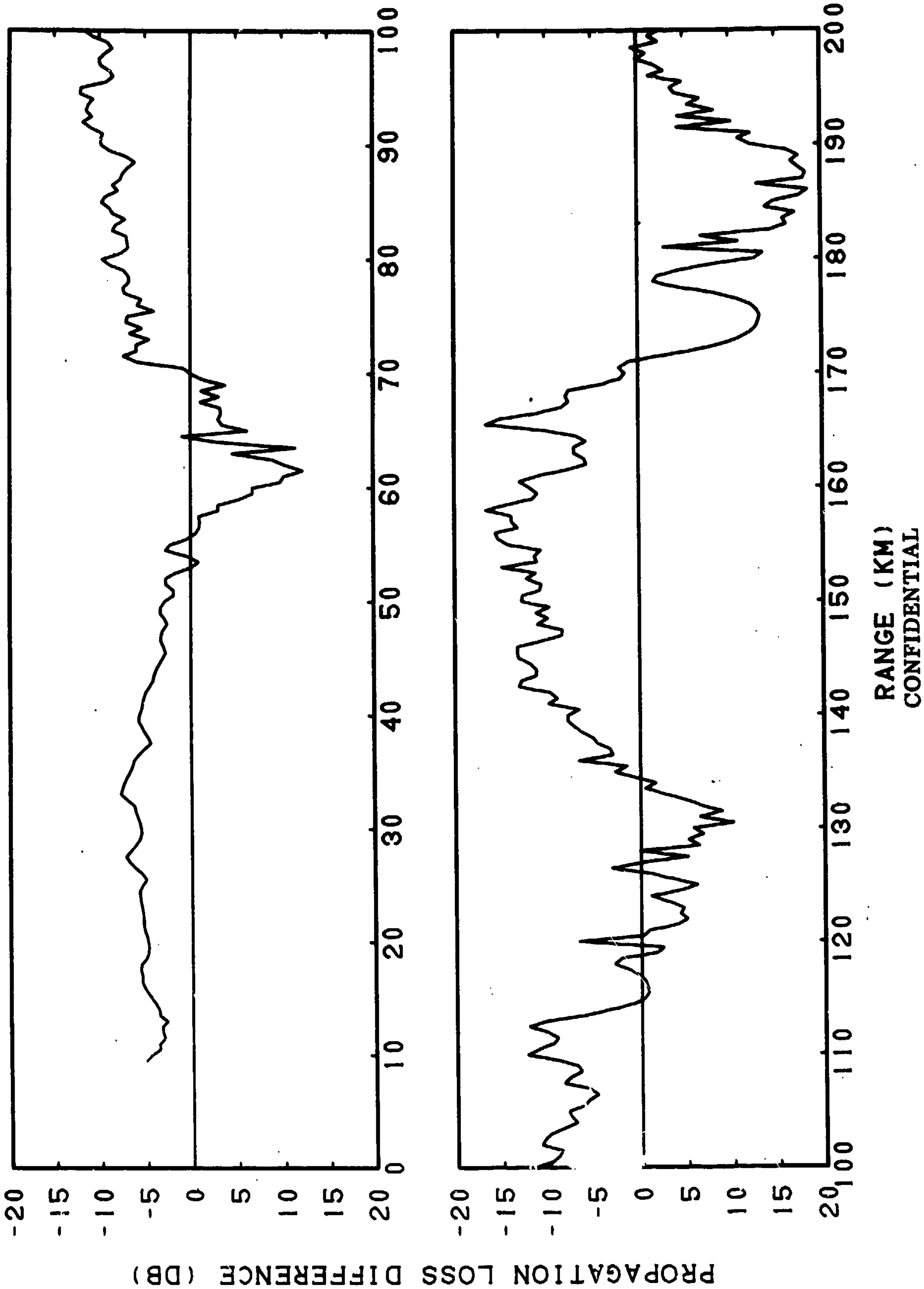
CONFIDENTIAL

(C) Figure IIIC-20. Smoothed RAYMODE X (Coherent), Bottom Loss = MGS 6, Frequency = 400 Hertz, Subtracted from PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 400 Hertz

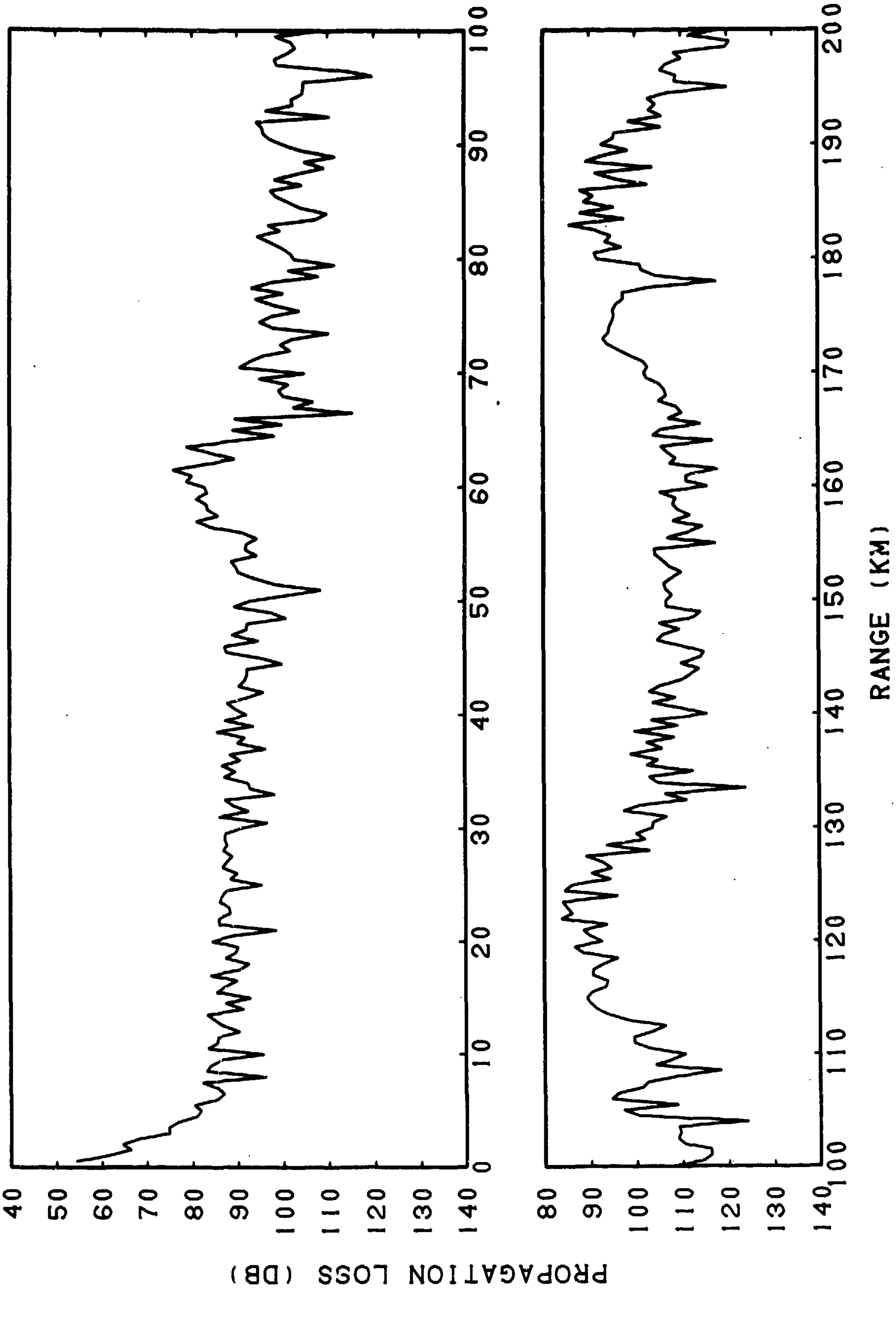


CONFIDENTIAL

(C) Figure IIIC-21. RAYMODE X (Incoherent), Bottom Loss = MGS 6, Frequency = 400 Hertz

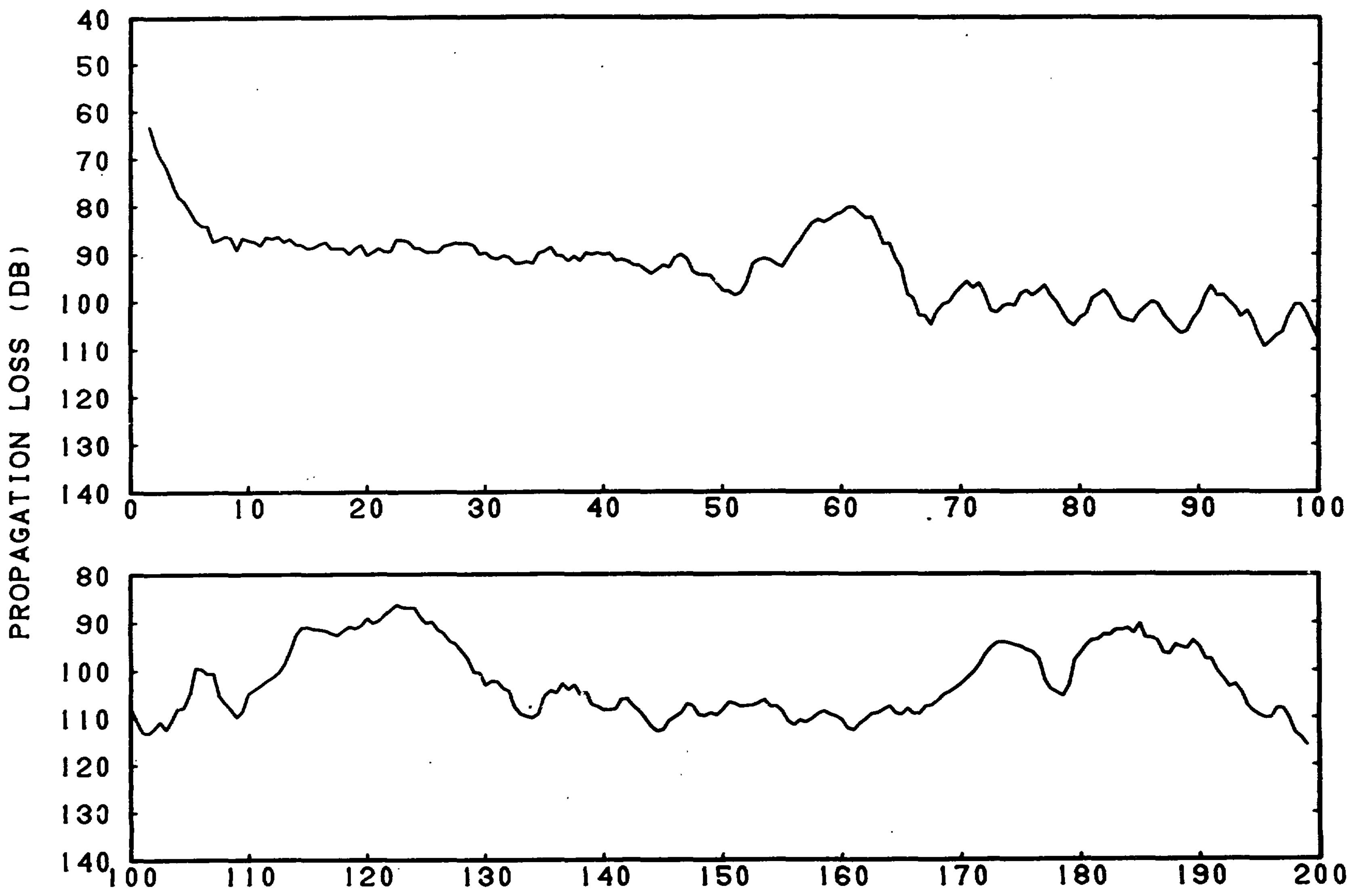


(C) Figure IIIC-22. RAYMODE X (Incoherent), Bottom Loss = MGS 6, Frequency = 400 Hertz, Subtracted from PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 400 Hertz



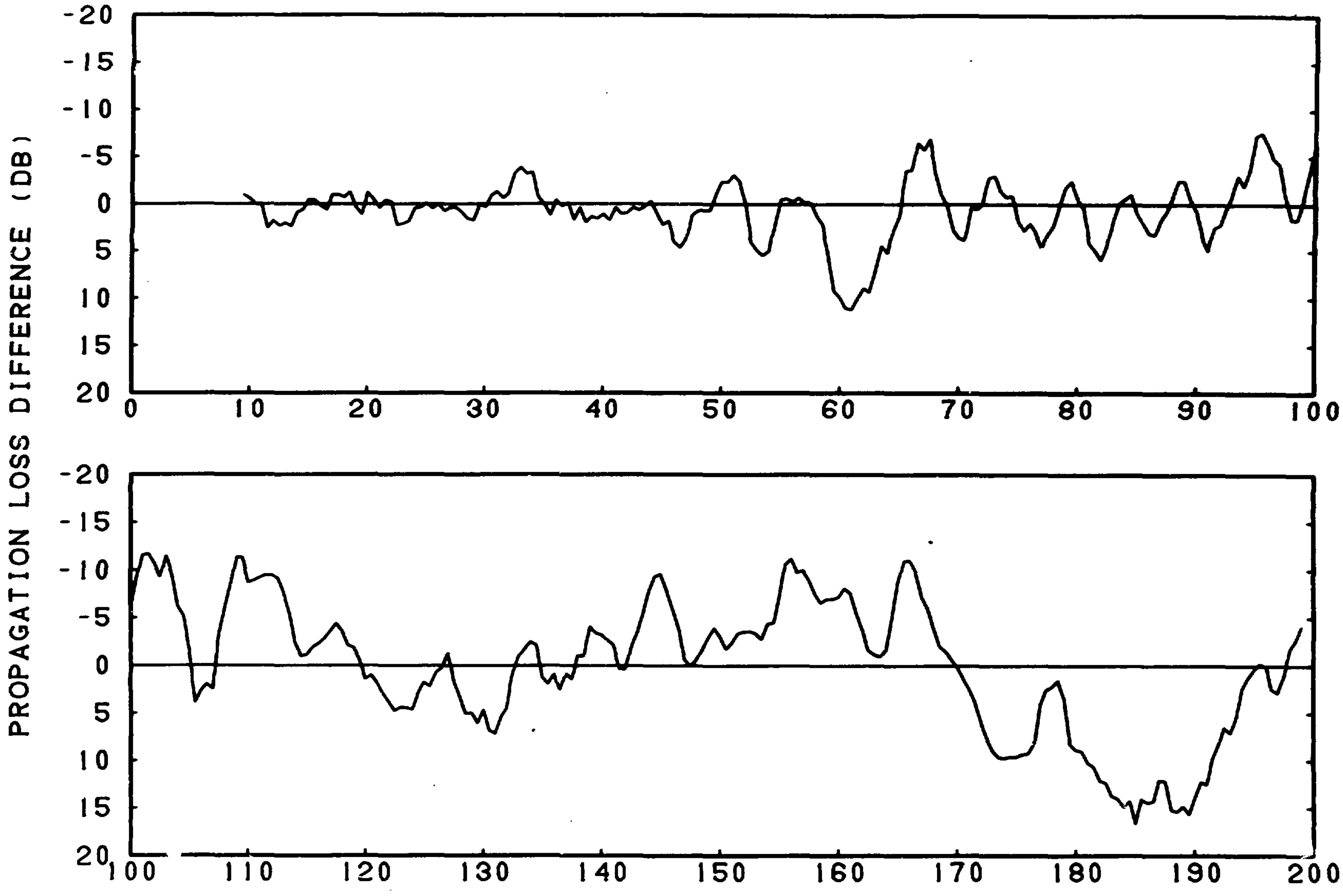
CONFIDENTIAL

(C) Figure IIIC-23. RAYMODE X (Coherent), Bottom Loss = FNOC Type 3, Frequency = 400 Hertz



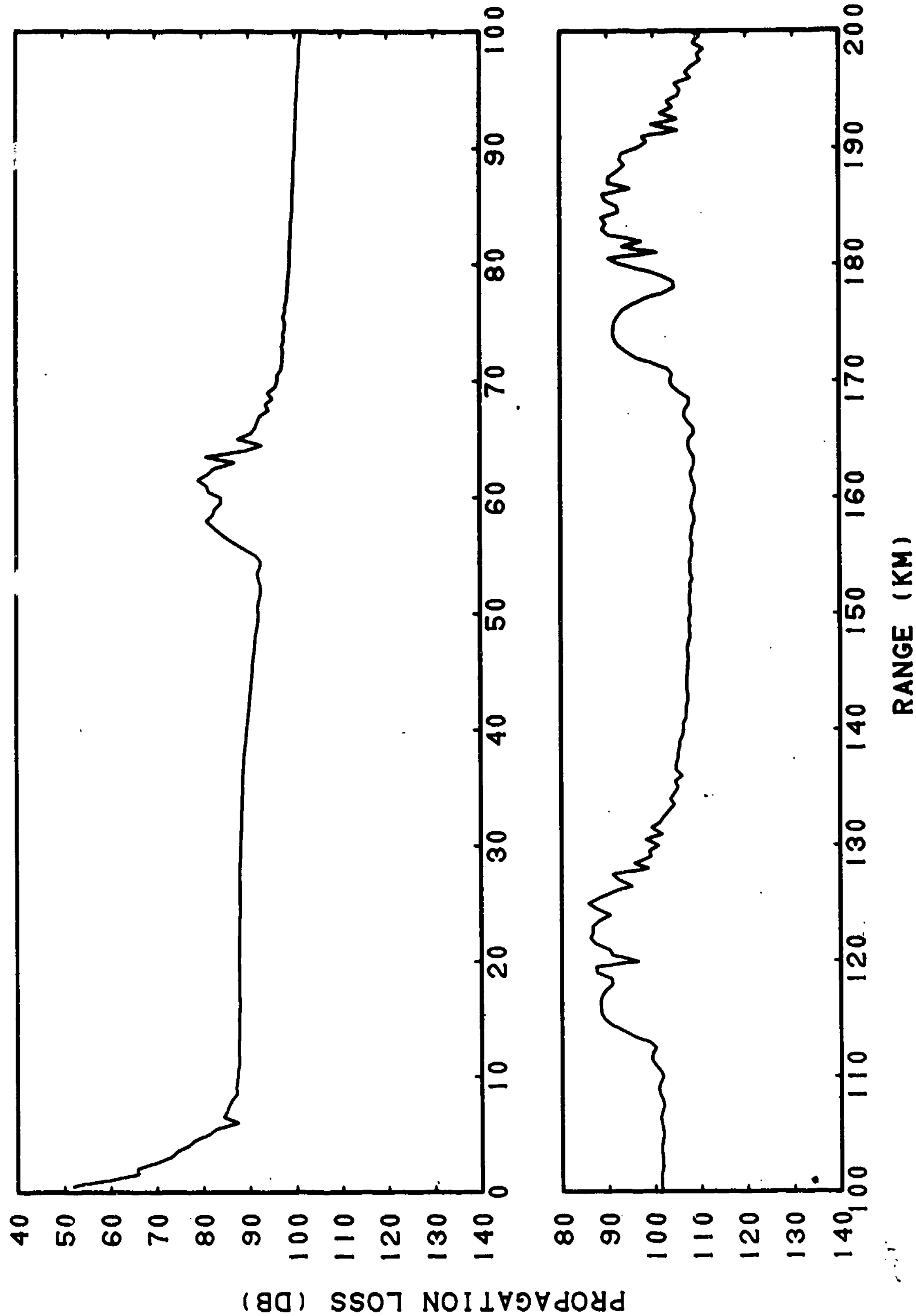
CONFIDENTIAL

(C) Figure IIIC-24. RAYMODE X (Coherent), Bottom Loss = FNOC Type 3, Frequency = 400 Hertz, Sliding Averages of 5 Points (2.00 Kilometers)



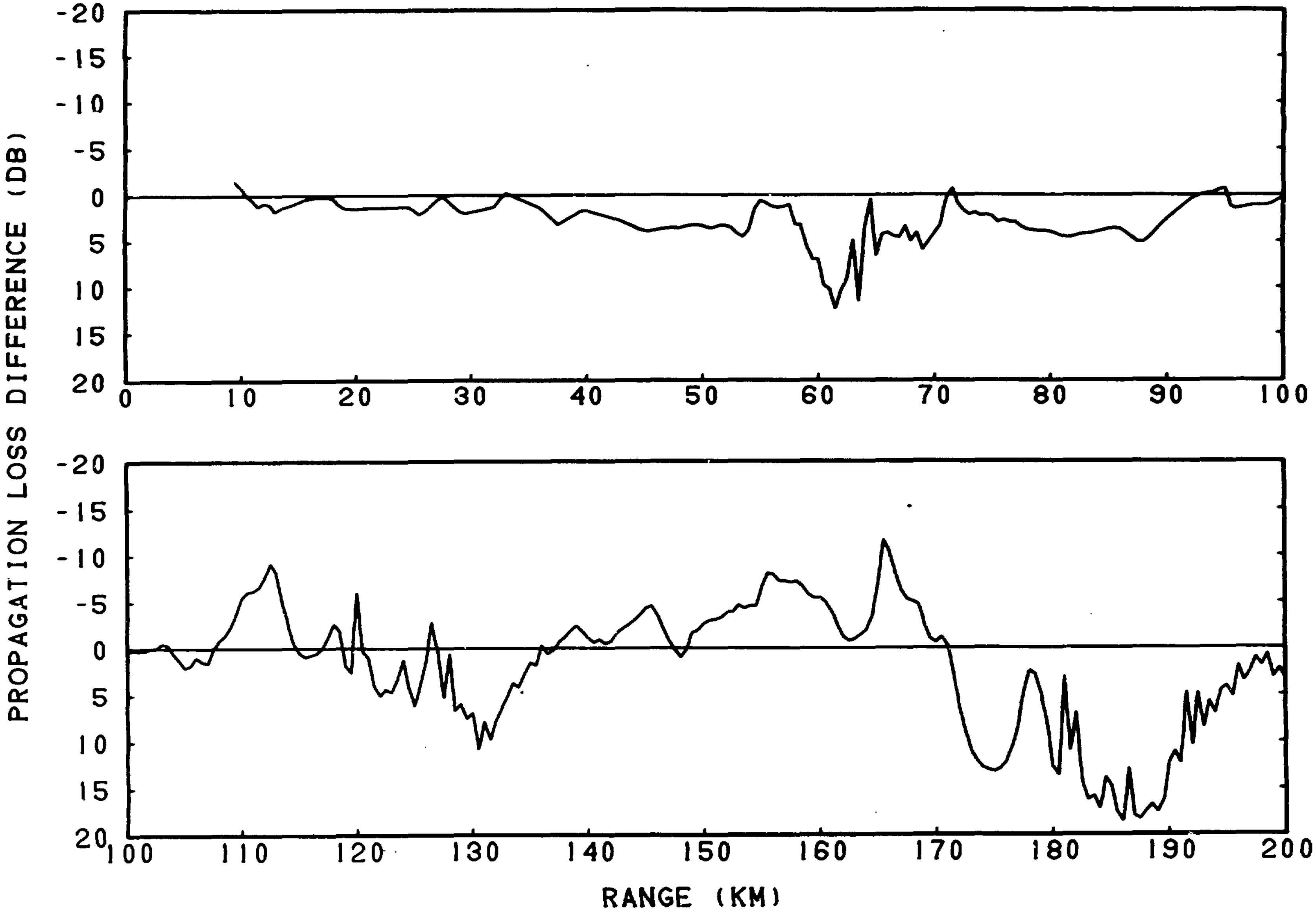
CONFIDENTIAL

(C) Figure IIIC-25. Smoothed RAYMODE X (Coherent), Bottom Loss = FNOC Type 3, Frequency = 400 Hertz, Subtracted from PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 400 Hertz



CONFIDENTIAL

(C) Figure IIIC-26. RAYMODE X (Incoherent), Bottom Loss = FNOC Type 3, Frequency = 400 Hertz



CONFIDENTIAL

(C) Figure IIIC-27. RAYMODE X (Incoherent), Bottom Loss = FNOC Type 3, Frequency = 400 Hertz, Subtracted from PARKA Data, Source Depth = 500 Feet, Receiver Depth = 300 Feet, Frequency = 400 Hertz

Appendix IIID. (U) Accuracy Assessment of RAYMODE X Compared to BEARING STAKE Experimental Data

BEARING STAKE (U)

Environment (U)

(C) The sound speed profile for station 1B, run P1, is given in Figure IIID-1. The profile is characterized by a broad, deep sound channel,the breadth evidenced by a variation of 1 m/sec from 1500 m to the sound channel axis at 1725 m and a 1 m/sec increase to a depth of approximately 2000 m. This profile is severely bottom limited.

(C) The bottom loss versus grazing angle for this environment is given in Figures IIID-2-4 and Tables IIID1-IIID3 for 25, 140 and 290 Hz. At all frequencies the bottom loss is 0 dB at 0 degrees and 11.2 dB at normal incidence. At 5°, the losses at 25, 240 and 290 Hz are 0.15, 0.73 and 1.27 dB, respectively. At 15° the losses are 0.58, 1.83 and 3.15 dB. These experimentally determined bottom losses are lower than the RAYMODE internally stored values for a type 1 area designator, the lowest loss routinely available to this model.

Test Cases (U)

(C) Station 1B, Run P1 consists of 12 cases as follows:

CASE	SOURCE DEPTH (m)	RECEIVER DEPTH (m)	FREQUENCY (Hz)
I	91	496	25
II	91	1685	25
III	91	3320	25
IV	91	3350	25
V	18	496	140
VI	18	1685	140
VII	18	3320	140
VIII	18	3350	140
IX	18	496	290
X	18	1685	290
XI	18	3320	290
XII	18	3350	290

(C) In all cases the source is relatively shallow at 18 or 91 m. Receiver depths vary from about 500 m to the depth of the sound channel axis to the bottom and 30 m off the bottom. The maximum range of the experimental data is 286 km. The RAYMODE X model was run to this range with a uniform spacing of 1 km between points. The Bearing Stake data for the 12 test cases are plotted in Figures IIID-5-16. The Bearing Stake experimental data are seen to exhibit substantial fluctuations and, in order to compare mean levels of model and experimental results, the experimental data were smoothed by application of a running average with a 2 km window. The smoothed experimental data for the 12 cases are given in Figures IIID-17-28.

Accuracy Assessment Results (U)

(U) The accuracy assessment procedures were followed as outlined in section 1.1 and described in detail in section 5 of Volume I of this series. The following figures were produced for each case: (1) RAYMODE X output using the coherent phase addition option, (2) RAYMODE X coherent output subtracted from the smoothed Bearing Stake experimental data, (3) RAYMODE X output using the incoherent phase addition option, and (4) RAYMODE X incoherent results subtracted from the smoothed Bearing Stake experimental data. The plots are given for each case successively in Figures IIID-29-76. The means and standard deviations of differences between the smoothed Bearing Stake data and the RAYMODE X model results are given in Table IIID-4. It is important to quantify the effects of the use of the 2 km window sliding average on the mean and standard deviation of the differences between experimental data and model results as compared to no averaging. Note: The 2 km window running average is equivalent to

a sonar system which integrates signal for five minutes when detecting a 12 knot target opening (or closing) range to own-ship on a bearing of 180° (or 0°). Means and standard deviations between Bearing Stake and RAYMODE X results were calculated for the Bearing Stake data used with and without smoothing. In general, the means for the unsmoothed results are about 0.2 dB greater (i.e., more positive) than those for the smoothed Bearing Stake data and the standard deviation is approximately 1 dB less. The difference in the two mean values is of an insignificant amount. The difference of the standard deviations, although not great, is significant and clearly in the proper direction. The overall effects of smoothing the experimental data were consistent and not very great.

(C) The Bearing Stake data did not have clearly definable regions although some near-field interference patterns are in evidence. It was for this reason that the means and standard deviations were calculated over the entire 286 km range extent. As will be seen below, this choice was not very useful and an arbitrary set of intervals such as 0-25, 25-50, 50-100, 100-200, >200 km would have been more useful.

(C) Conclusions based upon examining the difference curves follow: For Case I, the smoothed BEARING STAKE data is largely at the peaks of the RAYMODE X coherent prediction to about 150 km and clearly above (i.e., showing less loss) the RAYMODE curve past 170 km. For RAYMODE incoherent, the Bearing Stake data has less loss than the RAYMODE curve at almost all points past 80 km. For Case II, the JOAST data shows less loss than does the RAYMODE predictions. The discrepancy increases with range from mean differences of 3-5 dB for ranges less than 90 km to 12-15 dB at the full range extent of 286 km. In Case III, the structure of the Bearing Stake data is well emulated to a range of 60 km by applying a 5 dB offset of the RAYMODE result to lower values of propagation loss. At the farthest ranges, an offset of 17 dB would be required to align the two data sets. In Case IV, the structure at short ranges (to about 25 km) observed in the coherent model output is not seen in the Bearing Stake data. From 25 to 90 km, the mean difference is 3-5 dB. Past this range the mean difference between the curves increases rapidly, eventually to greater than 20 dB. The model shows strong interference patterns which lengthen with range. Such behavior is not observed in the Bearing Stake results. Some of these effects are somewhat mollified with respect to the incoherent RAYMODE X curve. For Case V, the interference structure of the Bearing Stake data is not seen in the model result, particularly between 25 and 45 km. To about 30 km the mean difference is positive indicating the model shows less loss than the Bearing Stake data. Past about 70 km this trend is reversed and the model shows increasingly greater loss than the experimental data with increasing range. In Case VI, agreement is basically good to 75 km, after which the experimental data exhibits increasingly less loss with respect to the RAYMODE X results. In Case VII, there is similarity in the basic interference patterns shown by Bearing Stake and RAYMODE to a range of 60 km, but the phasing of these patterns differs. Past 60 km, the model result shows increasingly greater loss than the Bearing Stake data with increasing range, as usual. In Case VIII, both model and experiment show strong interference patterns to 60 km but little or no agreement in their structure, causing large oscillations in the difference curve. RAYMODE shows increasingly greater propagation loss than Bearing Stake with increasing range. In Case IX, generally good agreement between RAYMODE coherent and Bearing Stake curves are seen to about 45 km; other range intervals of basically good agreement are 60 to 70, 90 to 105, and 125 to 140 km. Interlaced intervals of strong disagreement are due to low loss features in the Bearing

Stake data. Past 150 km, RAYMODE always predicts greater loss than is observed in Bearing Stake experimental results. In Case X, with the exception of some high loss peaks in the coherent output, RAYMODE and Bearing Stake results are in basic agreement to a range of 140 km. Past 140 kilometers the RAYMODE result falls off at a much faster rate than does the Bearing Stake data. In Case XI, both coherent RAYMODE and Bearing Stake show strong interference patterns. The patterns show some similarity but are out of phase to 40 km; from 40 to 105 km the interference patterns seem unrelated. The lack of coincidence of these large interference patterns is responsible for large oscillations of the difference curve. This effect is lessened for the incoherent RAYMODE comparison with Bearing Stake. Past 150 km, the difference curve is seen to increasingly rise to more negative values, indicating higher and higher loss for model as compared to experiment with increasing range. For Case XII, the RAYMODE coherent prediction shows much stronger interference patterns to 100 km than are observed in the Bearing Stake experimental data, causing large oscillations in the difference curve. These oscillations are superimposed on a trend from positive values of difference ($\mu \approx 5$ dB) at short ranges (10 km) to zero mean in the neighborhood of 100 km, to large negative differences ($\mu \approx -13$ dB) at long range (280 km). The same trend is clearer for the incoherent RAYMODE versus Bearing Stake comparison since the large interference pattern oscillations are not present.

(C) We now see how the above is reflected in the figure of merit (FOM) analysis. This analysis technique is demonstrated in section 1 of this volume and in section 5 of Volume I in greater detail. The result is detection coverage for various values of FOM (in 5 dB steps) for the Bearing Stake experimental data (unsmoothed), the RAYMODE X coherent result, and the RAYMODE X incoherent result. For Case I, Bearing Stake data shows greater detection coverage than do RAYMODE results for FOM $\geq$ 75 dB. At FOM = 80 dB, RAYMODE coherent has the greatest detection coverage, followed by Bearing Stake data and RAYMODE incoherent, in that order. For FOM = 85 and 90 dB, Bearing Stake and RAYMODE coherent have similar detection coverage both of which are much greater than RAYMODE incoherent coverage results. For FOM $\geq$ 95 dB, long and comparable detection coverage is found between the model and experimental data. For Case II, Bearing Stake experimental data lead to greater detection coverage than predicted by the RAYMODE X model, regardless of coherence option, at all FOMs. This superior detection coverage is in terms of both maximum range and percentage of the time detection can be made in a given range interval. For Case III, detection coverage is 30% longer for Bearing Stake data compared to the RAYMODE X prediction at FOM = 75 dB. This difference becomes greater at higher FOMs; at FOM = 80 dB, Bearing Stake detection coverage is three times longer than RAYMODE's. For FOM $\geq$ 95 dB, both experiment and model predict coverage to 285 km; but Bearing Stake, due to continuous coverage, can detect a greater percentage of the time than RAYMODE with its intermittent coverage. Detection coverage results for Case IV are quite similar to those for Case III. For Case V, detection coverage is short (4-5 km) at FOM = 75 dB for both model and experiment. For higher FOMs (80-90 dB) detection coverage is much greater for Bearing Stake data than for RAYMODE incoherent predictions comparable for RAYMODE coherent predictions. For FOM$\geq$95 dB, maximum detection coverage range and/or percentage of coverage is greater for Bearing Stake results than for RAYMODE predictions. For Case VI, at FOM$\leq$85 dB, Bearing Stake and coherent RAYMODE detection coverage results are in basic agreement with RAYMODE X incoherent predicting comparatively pessimistic detection coverage. For FOM$\geq$90 dB Bearing Stake gives better detection coverage than does RAYMODE, the discrepancy increasing with increasing FOM in terms of maximum detection range and/or percentage coverage. For

Case VII, Bearing Stake and RAYMODE give similar detection coverage for FOM = 75 and 80 dB. For FOM $\geq$ 85 dB, Bearing Stake coverage is longer and stronger than RAYMODE's by factors as great as 2 to 1. For Case VIII, Bearing Stake and RAYMODE X coherent give similar detection coverage for FOM $\leq$ 85 dB. At FOM = 85 dB, RAYMODE incoherent is pessimistic. At FOM $\geq$ 90 dB, Bearing Stake data yield longer detection ranges with higher percentage coverage than do RAYMODE predictions. For Case IX, Bearing Stake and RAYMODE detection coverage is similar for FOM $\leq$ 90 dB with the exception of a pessimistic RAYMODE incoherent result at FOM = 90 dB. At FOM $\geq$ 95 dB, Bearing Stake yields superior detection coverage to RAYMODE. For Case X, detection coverage between RAYMODE and Bearing Stake results is comparable (with coherent RAYMODE being closer to Bearing Stake than incoherent RAYMODE which is pessimistic) at FOM $\leq$ 95 dB. Past this FOM, Bearing Stake gives longer and more complete detection coverage than does RAYMODE. For Case XI, RAYMODE gives slightly better detection coverage than Bearing Stake for FOM $\leq$ 95 dB. For FOM $\geq$ 100 dB, however, Bearing Stake yields detection coverage far greater than RAYMODE predicts. Results for Case XII are roughly similar to those for Case XI.

(C) <u>General Conclusions:</u> (a) RAYMODE X coherent predictions are in better agreement with Bearing Stake data than are RAYMODE X incoherent predictions, (b) agreement between RAYMODE and Bearing Stake results are often in reasonable agreement to ranges from as far as 60 to 150 km, (c) in the difference curves, there is an underlying trend causing the difference between Bearing Stake and RAYMODE results to become increasingly negative with range. This suggests that a higher critical angle in the bottom loss versus grazing angle curve would lead to better agreement, offsetting this trend. (d) Bearing Stake data for the receiver on and 30 m off the bottom show strong interference patterns. RAYMODE X predictions show patterns which are generally out of phase with those of Bearing Stake at short ranges (<30 km) and dissimilar at longer ranges. The RAYMODE interference patterns are generally stronger (i.e., greater peak-to-peak excursion) than are those of Bearing Stake. (e) Detection coverage results are usually in rough agreement for figures of merit of 75 and 80 dB between RAYMODE X predictions and Bearing Stake data. This agreement often extended to 85 and 90 dB and in one case to 95 dB. (f) For FOM $\geq$ 95 dB, Bearing Stake detection coverage was to much longer range and was more complete (i.e., better percentage coverage).

(C) Table IIID-1. Bearing Stake Station 1B, Run P1. Bottom Loss (dB) versus Grazing Angle (degrees). Frequency = 25 Hertz

θ	BL	θ	BL	θ	BL	θ	BL	θ	BL	θ	BL
0	0.00	15	0.55	30	4.20	45	10.40	60	11.20	75	11.20
1	0.05	16	0.70	31	4.80	46	10.45	61	11.20	76	11.20
2	0.075	17	0.85	32	5.60	47	10.50	62	11.20	77	11.20
3	0.10	18	1.00	33	6.20	48	10.60	63	11.20	78	11.20
4	0.15	19	1.10	34	6.90	49	10.70	64	11.20	79	11.20
5	0.20	20	1.30	35	7.60	50	10.75	65	11.20	80	11.20
6	0.25	21	1.50	36	8.20	51	10.80	66	11.20	81	11.20
7	0.30	22	1.60	37	8.90	52	10.90	67	11.20	82	11.20
8	0.35	23	1.70	38	9.70	53	10.95	68	11.20	83	11.20
9	0.40	24	2.00	39	10.10	54	11.00	69	11.20	84	11.20
10	0.45	25	2.20	40	10.15	55	11.05	70	11.20	85	11.20
11	0.50	26	2.60	41	10.20	56	11.10	71	11.20	86	11.20
12	0.55	27	2.80	42	10.25	57	11.15	72	11.20	87	11.20
13	0.60	28	3.20	43	10.30	58	11.20	73	11.20	88	11.20
14	0.58	29	3.50	44	10.35	59	11.20	74	11.20	89	11.20

CONFIDENTIAL

(C) Table IIID-2. Bearing Stake Station 1B, Run P1. Bottom Loss (dB) versus Grazing Angle (degrees). Frequency = 140 Hertz.

Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL
0	0.00	15	1.83	30	4.13	45	10.43	60	11.20	75	11.20
1	0.13	16	1.83	31	4.33	46	10.53	61	11.20	76	11.20
2	0.33	17	1.83	32	4.63	47	10.63	62	11.20	77	11.20
3	0.53	18	1.91	33	5.03	48	10.73	63	11.20	78	11.20
4	0.79	19	2.13	34	5.63	49	10.74	64	11.20	79	11.20
5	0.93	20	2.23	35	6.23	50	10.83	65	11.20	80	11.20
6	1.18	21	2.33	36	6.93	51	10.84	66	11.20	81	11.20
7	1.33	22	2.43	37	7.53	52	10.85	67	11.20	82	11.20
8	1.53	23	2.63	38	8.13	53	10.86	68	11.20	83	11.20
9	1.53	24	2.83	39	8.63	54	10.92	69	11.20	84	11.20
10	1.68	25	2.93	40	9.13	55	10.93	70	11.20	85	11.20
11	1.73	26	3.23	41	9.63	56	10.94	71	11.20	86	11.20
12	1.78	27	3.33	42	10.13	57	11.01	72	11.20	87	11.20
13	1.83	28	3.63	43	10.23	58	11.02	73	11.20	88	11.20
14	1.83	29	3.83	44	10.33	59	11.03	74	11.20	89	11.20

CONFIDENTIAL

(C) Table IIID-3. Bearing Stake Station 1B, Run P1. Bottom Loss (dB) versus Grazing Angle (degrees). Frequency = 290 Hertz.

Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL	Θ	BL
0	0.00	15	3.17	30	6.37	45	10.67	60	11.20	75	11.20
1	0.27	16	3.18	31	6.57	46	10.87	61	11.20	76	11.20
2	0.67	17	3.19	32	6.77	47	11.07	62	11.20	77	11.20
3	0.97	18	3.37	33	6.97	48	11.20	63	11.20	78	11.20
4	1.27	19	3.57	34	7.47	49	11.20	64	11.20	79	11.20
5	1.57	20	3.77	35	7.97	50	11.20	65	11.20	80	11.20
6	1.87	21	3.97	36	8.27	51	11.20	66	11.20	81	11.20
7	2.17	22	4.19	37	8.67	52	11.20	67	11.20	82	11.20
8	2.37	23	4.57	38	9.27	53	11.20	68	11.20	83	11.20
9	2.47	24	4.77	39	9.67	54	11.20	69	11.20	84	11.20
10	2.67	25	5.17	40	9.77	55	11.20	70	11.20	85	11.20
11	2.77	26	5.37	41	9.97	56	11.20	71	11.20	86	11.20
12	2.87	27	5.67	42	10.17	57	11.20	72	11.20	87	11.20
13	3.07	28	5.97	43	10.27	58	11.20	73	11.20	88	11.20
14	3.15	29	6.17	44	10.47	59	11.20	74	11.20	89	11.20

CONFIDENTIAL

(C) Table IIID-4. Means (dB) and Standard Deviations (dB) Between Smoothed Bearing Stake Data[1] and RAYMODE X Model Results.

Case	Station	Run	Source Depth (meters)	Receiver Depth (meters)	Frequency (Hertz)	RAYMODE X Coherent μ	RAYMODE X Coherent σ	RAYMODE X Incoherent μ	RAYMODE X Incoherent σ
I	1B	P1	91	496	25	-5.5	6.9	-3.7	4.3
II	1B	P1	91	1685	25	-7.7	6.5	-4.9	4.0
III	1B	P1	91	3320	25	-9.6	7.0	-6.6	4.8
IV	1B	P1	91	3350	25	-8.5	7.5	-6.4	3.6
V	1B	P1	18	496	140	-6.1	7.2	-4.8	5.0
VI	1B	P1	18	1685	140	-6.3	7.1	-5.1	4.3
VII	1B	P1	18	3320	140	-7.4	7.1	-7.2	5.2
VIII	1B	P1	18	3350	140	-6.1	7.9	-6.8	6.0
IX	1B	P1	18	496	290	-6.6	7.9	-5.3	6.1
X	1B	P1	18	1685	290	-6.0	8.1	-4.7	6.4
XI	1B	P1	18	4320	290	-3.8	8.4	-4.1	7.1
XII	1B	P1	18	4350	290	-2.4	7.8	-4.1	7.0

1. Smoothed by application of a 2 km window running average.

CONFIDENTIAL

(C) Table IIID-5. Detection Range in km as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and RAYMODE X Model Results. Case I: (Station 1B Run P1, Source Depth = 91 m, Receiver Depth = 496 m, Frequency = 25 Hz.)

Data Set	FOM	R_c[2]	Range > R_c
Bearing Stake	70	3.8	
RAYMODE X Coherent	70	2.3	
RAYMODE X Incoherent	70	3.0	
Bearing Stake	75	5.5	ZDC[3] 15%, 5.5-31 km
RAYMODE X Coherent	75	3.0	Coverage at 4.5, 10.5, 25.5 km
RAYMODE X Incoherent	75	5.0	
Bearing Stake	80	6.0	ZDC 50%, 6-32 km, ZDC 5-10%, 32-90.5 km
RAYMODE X Coherent	80	7.0	ZDC 35%, 9-45 km
RAYMODE X Incoherent	80	17.0	
Bearing Stake	85	6.5	ZDC 65%, 6.5-98 km; ZDC 15%, 90.5-175 km
RAYMODE X Coherent	85	15.0	ZDC 45%, 18.5-8[illegible]
RAYMODE X Incoherent	85	31.5	
Bearing Stake	90	65.5	ZDC 85%, 65.5-150 km; ZDC 30%, 150-243 km
RAYMODE X Coherent	90	18.0	ZDC 45%, 19.5-165 km
RAYMODE X Incoherent	90	93.0	100% coverage 109.5-115.5 and 120-123 km
Bearing Stake	95	76.5	ZDC 85% 235->287 km; 100% coverage (except for dropouts at 76, 168 km) to 235 km
RAYMODE X Coherent	95	31.5	ZDC 65%, 31.5-225 km
RAYMODE X Incoherent	95	172.5	100% coverage 177-193 km, 205.5-210 km and 217.5-220.5 km
Bearing Stake	100	77.0	100% coverage (except for dropouts at 76, 168 km) to >287 km
RAYMODE X Coherent	100	46.0	ZDC 70%, 46-283.5 km
RAYMODE X Incoherent	100	271.5	100% coverage 282->288 km

1. Smoothed by running average with 2 kilometer window.
2. R_c = Range to which detection coverage is continuous.
3. ZDC = Zonal Detection Coverage in percentage of indicated range interval over which detection can be made.

CONFIDENTIAL

(C) Table IIID-6. Detection Range in km as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and RAYMODE X Model Results.
Case II: (Station 1B Run P1, Source Depth = 91 m, Receiver Depth = 1685 m, Frequency = 25 Hz.)

Data Set	FOM	R_c[2]	Range > R_c
Bearing Stake	75	12.0	One small peak (1 point) at 19 km
RAYMODE X Coherent	75	8.0	
RAYMODE X Incoherent	75	9.0	
Bearing Stake	80	13.0	ZDC[3] 70%, 13-44 km
RAYMODE X Coherent	80	9.0	ZDC 15%, 13.0-36 km
RAYMODE X Incoherent	80	17.0	
Bearing Stake	85	25.0	ZDC 95%, 25-66 km; ZDC 50%, 66-119 km; ZDC 15%, 119-199 km
RAYMODE X Coherent	85	10.5	ZDC 35%, 12.0-70.5 km
RAYMODE X Incoherent	85	40.5	100% coverage 45-51 km
Bearing Stake	90	75.0	ZDC 95%, 75-144 km; ZDC 60%, 149-196 km; ZDC 10%, 196-186 km
RAYMODE X Coherent	90	16.5	ZDC 40%, 16.5-159.0 km
RAYMODE X Incoherent	90	91.5	
Bearing Stake	95	76.0	ZDC 95%, 76-256 km; ZDC 80%, 256 ->287 km
RAYMODE X Coherent	95	50.0	ZDC 50%, 82-216.0 km
RAYMODE X Incoherent	95	166.5	100% coverage 171-179 km, 192-198 km, and 212-216 km
Bearing Stake	100	> 287.0	
RAYMODE X Coherent	100	50.0	ZDC 70%, 51.0-264.0 km
RAYMODE X Incoherent	100	225.0	100% coverage 249-265 km, 270-283.5 km

1. Smoothed by running average with 2 kilometer window.
2. R_c = Range to which detection coverage is continuous.
3. ZDC = Zonal Detection Coverage in percentage of indicated range interval over which detection can be made.

CONFIDENTIAL

(C) Table IIID-7. Detection Range in km as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and RAYMODE X Model Results. Case III: (Station 1B Run P1, Source Depth = 91 m, Receiver Depth = 3320 m, Frequency = 25 Hz.)

Data Set	FOM	R_c[2]	Range > R_c
Bearing Stake	75	5.0	ZDC[3] 85%, 5-22 km
RAYMODE X Coherent	75	-----	100% coverage 1.5-3.0 km and 10.5-16.5 km
RAYMODE X Incoherent	75	-----	100% coverage 1.5-16.5 km
Bearing Stake	80	6.0	ZDC 90%, 6-71.5 km
RAYMODE X Coherent	80	-----	100% coverage 1.5-5 km and 9.0-17.0 km
RAYMODE X Incoherent	80	23.0	
Bearing Stake	85	75.0	ZDC 20%, 225-286 km; ZDC 65%, 75-140 km; ZDC 50%, 140-225 km
RAYMODE X Coherent	85	-----	100% coverage 1.0-7 km, 8-19 km, 30-47 km ZDC 10%, 48-82.5 km
RAYMODE X Incoherent	85	33.0	100% coverage 52.5-62 km
Bearing Stake	90	75.5	ZDC 90%, 75.5-286 km
RAYMODE X Coherent	90	19.5	100% coverage 22-25 km, and 28.5-52 km; ZDC 45%, 52.5-166.5 km
RAYMODE X Incoherent	90	109.5	100% coverage 133.5-138 km
Bearing Stake	95	76.0	100% coverage (except for dropouts at 76, 186 km) to >286 km
RAYMODE X Coherent	95	20.0	100% coverage 21-26 km, 28-84 km (except 54, 88 km); ZDC 40%, 85.5-222 km
RAYMODE X Incoherent	95	158.0	100% coverage 161-196 km; ZDC 25%, 201-285 km
Bearing Stake	100	76.5	100% coverage (except dropouts at 76, 168 km) to > 286 km
RAYMODE X Coherent	100	27.0	100% coverage 27-103.5 km, 105-124.5 km, 126-147 km and 148.5-163 km; ZDC 50%, 164.5-285 km
RAYMODE X Incoherent	100	237.0	100% coverage 238.5-250.5 km, 257-275 km, >278 km

1. Smoothed by running average with 2 kilometer window.

2. R_c = Range to which detection coverage is continuous.

3. ZDC = Zonal Detection Coverage in percentage of indicated range interval over which detection can be made.

(C) Table IIID-8. Detection Range in km as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and RAYMODE X Model Results. Case IV: (Station 1B Run P1, Source Depth = 91 m, Receiver Depth = 3350 m, Frequency = 25 Hz.)

Data Set	FOM	R_c[2]	Range > R_c
Bearing Stake	75	6.0	ZDC[3] 95%, 6-19 km
RAYMODE X Coherent	75		100% coverage, 1.5-7.5 km, 9-16 km, and 19 km
RAYMODE X Incoherent	75		100% coverage 1.5-16.5 km
Bearing Stake	80	35.0	ZDC 60%, 35-69 km; 100% coverage 87-90 km
RAYMODE X Coherent	80		100% coverage 1.5-7.5 km, 9-16 km; ZDC 35%, 18-51 km
RAYMODE X Incoherent	80	23.0	
Bearing Stake	85	80.0	ZDC 70%, 80-150 km, ZDC 20%, 150-186 km
RAYMODE X Coherent	85		100% coverage 1.5-16 km, 17.5-19.5 km, 20-30 km, 27-28.5 km and 30-47 km. ZDC 45%, 48-91.5 km
RAYMODE X Incoherent	85	62.0	
Bearing Stake	90	150.0	ZDC 90%, 150-286 km
RAYMODE X Coherent	90		100% coverage 1.5-16.5 km, 17-23 km, 25.5-75 km (except dropouts at 27, 52 km). ZDC 50%, 75-173 km
RAYMODE X Incoherent	90	109.5	100% coverage 135-138 km
Bearing Stake	95	>286.0	
RAYMODE X Coherent	95		100% coverage 1.5-96 km (except dropouts at 24, 48, 85 km) ZDC 60%, 100.5-224.5
RAYMODE X Incoherent	95	158.0	100% coverage 160.5-196 km ZDC 20%, 201-286 km
Bearing Stake	100	>286.0	
RAYMODE X Coherent	100		100% coverage 1.5-124.5 km (except dropouts at 100 km, 103.5 km) ZDC 65%, 126-257.5 km
RAYMODE X Incoherent	100	273.0	ZDC 75% 238.5->286 km

1. Smoothed by running average with 2 kilometer window.
2. R_c = Range to which detection coverage is continuous.
3. ZDC = Zonal Detection Coverage in percentage of indicated range interval over which detection can be made.

(C) Table IIID-9. Detection Range in km as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and RAYMODE X Model Results. Case V: (Station 1B Run P1, Source Depth = 18 m, Receiver Depth = 496 m, Frequency = 140 Hz.)

Data Set	FOM	R_c [2]	Range > R_c
Bearing Stake	75	5.0	
RAYMODE X Coherent	75	4.0	
RAYMODE X Incoherent	75	4.5	
Bearing Stake	80	6.0	100% coverage 30.5-34 km
RAYMODE X Coherent	80	4.5	100% coverage 10.5-13.5 km, 27-29 km; Peaks at 6, and 31.5 km
RAYMODE X Incoherent	80	5.0	
Bearing Stake	85	7.0	ZDC[3] 50% 7-41 km
RAYMODE X Coherent	85	7.5	ZDC 65% 7.5-36 km, peaks at 49 and 55.5 km
RAYMODE X Incoherent	85	34.5	
Bearing Stake	90	8.0	100% coverage 11-44 km ZDC 55%, 44-115 km
RAYMODE X Coherent	90	15.0	100% coverage 15.5-37 km; ZDC 40%, 40.5-94.5 km
RAYMODE X Incoherent	90	66.0	
Bearing Stake	95	41.0	ZDC 75%, 41-150 km ZDC 15%, 150-247.5 km
RAYMODE X Coherent	95	38.0	ZDC 45% 40-139 km
RAYMODE X Incoherent	95	102.0	
Bearing Stake	100	136.5	ZDC 95%, 136.5-249 km
RAYMODE X Coherent	100	38.0	ZDC 65% 39-145 km, ZDC 10% 151-204 km
RAYMODE X Incoherent	100	142.5	
Bearing Stake	105	251.0	ZDC 90%, 251-286 km
RAYMODE X Coherent	105	43.5	100% coverage 45-139.5 km (except dropouts at 89.0 km, 103.5 km, and 124.5 km); ZDC 55%, 141-235 km
RAYMODE X Incoherent	105	195.0	

1. Smoothed by running average w[illegible] kilometer window.
2. R_c = Range to which detection coverage is continuous.
3. ZDC = Zonal Detection Coverage in percentage of indicated range interval over which detection can be made.

(C) Table IIID-10. Detection Range in km as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and RAYMODE X Model Results. Case VI: (Station 1B Run P1, Source Depth = 18 m, Receiver Depth = 1685 m, Frequency = 140 Hz.)

Data Set	FOM	R_c[2]	Range > R_c
Bearing Stake	75	6.5	100% coverage, 8-10 km
RAYMODE X Coherent	75	4.5	100% coverage, 5-8 km; peak at 10 km
RAYMODE X Incoherent	75	9.0	
Bearing Stake	80	11.0	ZDC[3] 25%, 11-21 km
RAYMODE X Coherent	80	12.0	100% coverage 15-18 km, 19.5-22.5 km; peak at 23 km
RAYMODE X Incoherent	80	10.5	
Bearing Stake	85	15.5	ZDC 45%, 20-48 km
RAYMODE X Coherent	85	13.0	100% coverage 14-25.5 km, 31.5-37.5 km, 40.5-43 km Peaks at 26 km, 88 km, 46.5 km
RAYMODE X Incoherent	85	12.0	
Bearing Stake	90	43.5	ZDC 95%, 45-67 km; ZDC 25%, 67-115.5 km
RAYMODE X Coherent	90	13.5	100% coverage 14-28 km, 28.5-43.5; ZDC 65%, 45.0-70.5 km; Peaks at 83 km, 91.5 km
RAYMODE X Incoherent	90	60.0	
Bearing Stake	95	129.0	ZDC 85%, 129-150 km; ZDC 20%, 150-216.5 km
RAYMODE X Coherent	95	43.5	ZDC 45%, 44.0-124.5 km; Peaks at 145.5 km, 152 km
RAYMODE X Incoherent	95	96.0	
Bearing Stake	100	157.5	ZDC 85%, 157.5-226.5 km; ZDC 20%, 226.5-286 km
RAYMODE X Coherent	100	79.5	ZDC 55%, 81-180 km
RAYMODE X Incoherent	100	133.0	
Bearing Stake	105	162.0	100% coverage (except 162-166 km) to > 286 km
RAYMODE X Coherent	105	88.0	100% coverage 90-128 km; ZDC 40%, 130-243
RAYMODE X Incoherent	105	190.5	

1. Smoothed by running average with 2 kilometer window.
2. R_c = Range to which detection coverage is continuous.
3. ZDC = Zonal Detection Coverage in percentage of indicated range interval over which detection can be made.

(C) Table IIID-11. Detection Range in km as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and RAYMODE X Model Results. Case VII: (Station 1B Run P1, Source Depth = 18 m, Receiver Depth = 3320 m, Frequency = 140 Hz.)

Data Set	FOM	R_c [2]	Range > R_c
Bearing Stake	75	?	ZDC[3] 50% to 18.5 km
RAYMODE X Coherent	75	-----	100% coverage 1.5-3 km, 4.5-5 km, 6-7.5 km, 12-16.5 km
RAYMODE X Incoherent	75	-----	100% coverage 1.5-17 km
Bearing Stake	80	9	ZDC 80% 9-20 km; 100% coverage 45-50 km
RAYMODE X Coherent	80	-----	100% coverage 1.5-3 km, 4.5-8 km, 11-18 km
RAYMODE X Incoherent	80	-----	100% coverage 1.5-19 km
Bearing Stake	85	24	ZDC 50%, 24-84 km, ZDC 5% 84-130 km
RAYMODE X Coherent	85	4.0	100% coverage 4-9 km, 9-10.5 km, 11-20 km, 35-50 km; peak at 22.5 km
RAYMODE X Incoherent	85	20.0	
Bearing Stake	90	24	100% coverage (except for dropouts at 24, 59 km) to 141.5 km ZDC 15% 141.5-215.5 km
RAYMODE X Coherent	90	20.0	100% coverage 22-24 km, 34.5-54 km ZDC 70%, 58-85.5
RAYMODE X Incoherent	90	56.0	
Bearing Stake	95	141.5	ZDC 65%, 141-249 km
RAYMODE X Coherent	95	21.0	100% coverage 21-25.5 km, 33-85.5 km (except 61 km), 144-146 km ZDC 45%, 41-83 km, ZDC 80% 87-123
RAYMODE X Incoherent	95	94.0	
Bearing Stake	100	143	ZDC 15%, 143-286 km
RAYMODE X Coherent	100	85.5	100% coverage, 86-88.5 km, 89-125 km ZDC 55%, 127-196.5 km; peak at 213 km
RAYMODE X Incoherent	100	157.5	
Bearing Stake	105	253.5	100% coverage (except from 253.5 to 256 km) to 286 km
RAYMODE X Coherent	105	140.0	ZDC 65% 142.5-244 km
RAYMODE X Incoherent	105	202.5	

1. Smoothed by running average with 2 kilometer window.
2. R_c = Range to which detection coverage is continuous.
3. ZDC = Zonal Detection Coverage in percentage of indicated range interval over which detection can be made.

(C) Table IIID-12. Detection Range in km as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and RAYMODE X Model Results. Case VIII: (Station 1B Run P1, Source Depth = 18 m, Receiver Depth = 3350 m, Frequency = 140 Hz.)

Data Set	FOM	R_c [2]	Range > R_c
Bearing Stake	75	?	ZDC[3] 50%, 4-18 km
RAYMODE X Coherent	75	-----	100% coverage 1.5-3.5 km, 4.5-7.5 km, 10-18 km
RAYMODE X Incoherent	75	-----	100% coverage 1.5-16.5
Bearing Stake	80	10.5	100% coverage 12.5-20 km, 46-50 km
RAYMODE X Coherent	80	-----	100% coverage 1.5-8 km, 9-19 km; peak at 40.5 km
RAYMODE X Incoherent	80	-----	100% coverage 1.5-18.0 km
Bearing Stake	85	30.5	ZDC 50%, 30.5-57 km, ZDC 5%, 57-131.5 km
RAYMODE X Coherent	85	-----	100% coverage 1.5-22.5 km, 31-51 km
RAYMODE X Incoherent	85	21.0	
Bearing Stake	90	32.0	ZDC 75%, 32-100 km; ZDC 50%, 100-148 km
RAYMODE X Coherent	90	-----	100% coverage 1.5-24 km, 28.5-53 km, 55-59 km, 60-76.5 km, ZDC 45%, 79-88.5; peaks at 97.5 km, 114.5 km, 117 km
RAYMODE X Incoherent	90	55.5	
Bearing Stake	95	34.0	100% coverage (except 34-37 and 60-61 km) to 167; ZDC 50%, 165-233 km; ZDC 20%, 233-273 km
RAYMODE X Coherent	95	-----	100% coverage 1.5-26 km, 28.5-54 km, 55.5-84 km; ZDC 65%, 85-123 km, ZDC 25%, 134-166.5 km
RAYMODE X Incoherent	95	93.0	
Bearing Stake	100	254.0	ZDC 50%, 254-286 km
RAYMODE X Coherent	100	-----	100% coverage 1.5-26 km, 28-85.5 km (except dropouts at 54 and 84 km); 86-111 km, 112.5-129 km, ZDC 55%, 131-196.5 km
RAYMODE X Incoherent	100	157.5	
Bearing Stake	105	255.0	100% coverage (except 255-258 km) to >286 km
RAYMODE X Coherent	105	27.0	100% coverage 27-147 km (except dropout at 86 km) ZDC 70%, 148.5-232 km
RAYMODE X Incoherent	105	201.0	

1. Smoothed by running average with 2 kilometer window.
2. R_c = Range to which detection coverage is continuous.
3. ZDC = Zonal Detection Coverage in percentage of indicated range interval over which detection can be made.

(C) Table IIID-13. Detection Range in km as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and RAYMODE X Model Results.
Case IX: (Station 1B Run P1, Source Depth = 18 m, Receiver Depth = 496 m, Frequency = 290 Hz.)

Data Set	FOM	R_c[2]	Range > R_c
Bearing Stake	75	4.5	
RAYMODE X Coherent	75	4.0	
RAYMODE X Incoherent	75	4.0	
Bearing Stake	80	5.5	
RAYMODE X Coherent	80	5.0	Peak at 15 km
RAYMODE X Incoherent	80	6.0	
Bearing Stake	85	8.0	ZDC[3] 25%, 8-37 km
RAYMODE X Coherent	85	10.0	ZDC 45%, 13-38 km
RAYMODE X Incoherent	85	33.0	
Bearing Stake	90	23.0	ZDC 90%, 23-44 km; ZDC 25%, 44-84 km; ZDC 5%, 84-183 km
RAYMODE X Coherent	90	11.0	100% coverage, 12-16 km, 16-17 km, 18-31.5 km; ZDC 80%, 33-46 km; ZDC 40%, 61.5-70.5 km
RAYMODE X Incoherent	90	41.0	
Bearing Stake	95	50.5	ZDC 70%, 50.5-90 km; ZDC 15%, 90-183 km
RAYMODE X Coherent	95	17.5	100% coverage (except dropouts at 17.5, 39 km) to 46 km; ZDC 50%, 48-78 km; peaks at 94.5 and 97 km
RAYMODE X Incoherent	95	73.5	
Bearing Stake	100	60.5	ZDC 95%, 60.5-89.5 km; ZDC 60%, 89.5-208 km
RAYMODE X Coherent	100	31.5	ZDC 60%, 48-106.5 km; peaks at 111 km, 118 km, and 130.5 km
RAYMODE X Incoherent	100	108.0	
Bearing Stake	105	93.0	ZDC 90%, 93-163 km; ZDC 75%, 163-237.5 km
RAYMODE X Coherent	105	46.5	100% coverage, 47-82 km (except dropouts at 52.5, 64 km) ZDC 50%, 83-165 km
RAYMODE X Incoherent	105	144.0	
Bearing Stake	110	173.0	ZDC 95%, 173-258 km; ZDC 35%, 258-286 km
RAYMODE X Coherent	110	46.5	100% coverage, 47-111 km (except dropout at 82.5 km); ZDC 60%, 119-222 km
RAYMODE X Incoherent	110	181.0	

1. Smoothed by running average with 2 kilometer window.
2. R_c = range to which detection coverage is continuous.
3. ZDC = Zonal Detection Coverage in percentage of indicated range interval over which detection can be made.

(C) Table IIID-14. Detection Range in km as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and RAYMODE X Model Results. Case X: (Station 1B Run P1, Source Depth = 18 m, Receiver Depth = 1685 m, Frequency = 290 Hz.)

Data Set	FOM	R_c[2]	Range > R_c
Bearing Stake	75	6.5	
RAYMODE X Coherent	75	6.0	100% coverage 7.5-9 km
RAYMODE X Incoherent	75	9.0	
Bearing Stake	80	8.0	100% coverage 9-10.5 km
RAYMODE X Coherent	80	6.0	100% coverage 7.5-10.5 km, peak at 18 km
RAYMODE X Incoherent	80	10.5	
Bearing Stake	95	12.0	ZDC[3] 70%, 12-31 km
RAYMODE X Coherent	85	12.0	100% coverage 13.5-18 km, 21-28 km; peak at 39 km
RAYMODE X Incoherent	85	27.0	
Bearing Stake	90	24.5	ZDC 35%, 29.5-63 km
RAYMODE X Coherent	90	12.0	ZDC 30%, 36-59 km; 100% coverage 13.5-18 km, 19.5-20 km, 21-31.5 km
RAYMODE X Incoherent	90	45.0	
Bearing Stake	95	36.0	ZDC 80%, 36-69 km; ZDC 40% 69-108 km
RAYMODE X Coherent	95	19.0	100% coverage (except dropouts at 19 and 33 km) to 48 km ZDC 35%, 50-99 km
RAYMODE X Incoherent	95	65.0	
Bearing Stake	100	69.5	ZDC 90%, 69.5-100 km; ZDC 35%, 100-127.5 km; 100% coverage 182-186 km
RAYMODE X Coherent	100	48.0	100% coverage 50-52.5 km, 54-56 km, 57-81 km ZDC 40%, 80-108 km
RAYMODE X Incoherent	100	97.5	
Bearing Stake	105	101.0	ZDC 65%, 101-286 km
RAYMODE X Coherent	105	48.0	100% coverage 49.5-81 km (except dropouts at 52.5, 55.5 km) ZDC 45%, 84-151 km
RAYMODE X Incoherent	105	129.0	
Bearing Stake	110	204.5	ZDC 90%, 204.5-286 km.
RAYMODE X Coherent	110	81.0	100% coverage 82.5-116 km (except dropouts at 94.5, 108 km) ZDC 40% 117-193.5 km
RAYMODE X Incoherent	110	169.0	
Bearing Stake	115	>286.0	
RAYMODE X Coherent	115	94.5	100% coverage (except dropouts at 94.5, 117, 135 km) to 148.5 km ZDC 55%, 150-242 km
RAYMODE X Incoherent	115	221.0	

1. Smoothed by running average with 2 kilometer window.
2. R_c = Range to which detection coverage is continuous.
3. ZDC = Zonal Detection Coverage in percentage of indicated range interval over which detection can be made.

CONFIDENTIAL

(C) Table IIID-15. Detection Range in km as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and RAYMODE X Model Results. Case XI: (Station 1B Run P1, Source Depth = 18 m, Receiver Depth = 3320 m, Frequency = 290 Hz.)

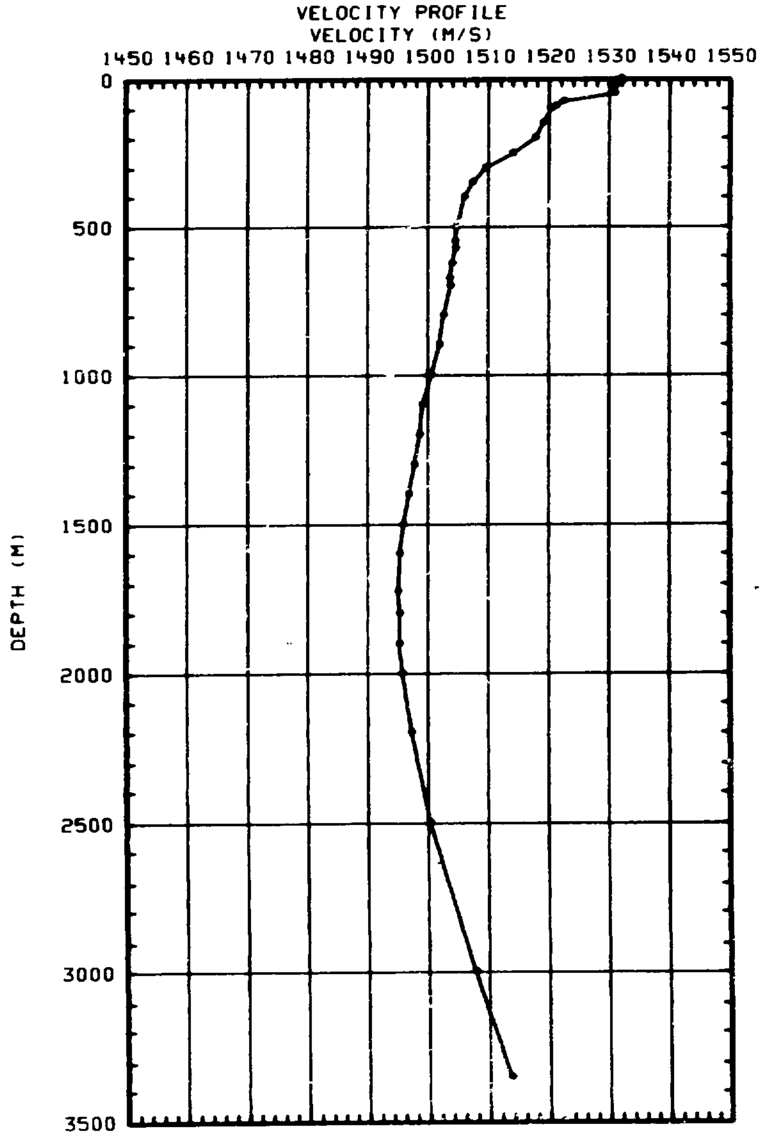
Data Set	FOM	R_c[2]	Range > R_c
Bearing Stake	75	8.0	
RAYMODE X Coherent	75	-----	ZDC[3] 60%, 1.5-19 km
RAYMODE X Incoherent	75	-----	100% coverage 1.5-10.5 km
Bearing Stake	80	11.0	100% coverage 12-14 km
RAYMODE X Coherent	80	-----	ZDC 75%, 1.5-19 km
RAYMODE X Incoherent	80	-----	100% coverage 1.5-18 km
Bearing Stake	85	18.5	100% coverage 27-31.5 km
RAYMODE X Coherent	85	-----	ZDC 80%, 1.5-19.5 km; 100% coverage 31.5-34.5 km and 46.5-52 km
RAYMODE X Incoherent	85	-----	100% coverage 1.5-20 km
Bearing Stake	90	18.5	ZDC 45%, 18.5-56 km
RAYMODE X Coherent	90	-----	100% coverage (except dropouts at 9 km, 13.5 km, 21 km) 1.5-25.5 km and 30-37.5 km, 43.5-52.5 km; ZDC 60% 78-87 km; peak at 55.5 km
RAYMODE X Incoherent	90	-----	100% coverage 1.5-54 km
Bearing Stake	95	22.0	ZDC 75%, 22-75; ZDC 20%, 75-133 km
RAYMODE X Coherent	95	-----	100% coverage 1.5-26.5 km, 29-37.5 km, 43-52.5 km, 55-56 km, and 77-88.5 km; peaks at 42 km, 60 km, and 61.5 km
RAYMODE X Incoherent	95	-----	100% coverage 1.5-61.5 km and 81-87 km
Bearing Stake	100	25.0	ZDC 70% 25-163 km; ZDC 25% 163-238 km
RAYMODE X Coherent	100	28.0	100% coverage 29-38 km, 41-57 km, 58-64.5 km, 72-73.5 km; 75-93 km, 105-106.5 km, 108-123 km; peaks at 126 km, 140 km
RAYMODE X Incoherent	100	97.0	
Bearing Stake	105	79.0	100% coverage (with exception of 79-81 km and 134-135 km) to 141 km; ZDC 35%, 149-252 km
RAYMODE X Coherent	105	64.5	Peak at 69 km, 100% coverage 70.5-73.5 km, 74-96 km, 103.5-130 km; ZDC 75%, 133-158 km, 100% coverage 174-175.5 km
RAYMODE X Incoherent	105	136.5	
Bearing Stake	110	141.5	100% coverage (except for 5 dropouts) to >286 km
RAYMODE X Coherent	110	68.0	100% coverage (except dropouts at 68, 70.5, 96, 132 km) to 158 km ZDC 65%, 160-226.5 km
RAYMODE X Incoherent	110	178.5	

1. Smoothed by running average with 2 kilometer window.
2. R_c = Range to which detection coverage is continuous.
3. ZDC = Zonal Detection Coverage in percentage of indicated range interval over which detection can be made.

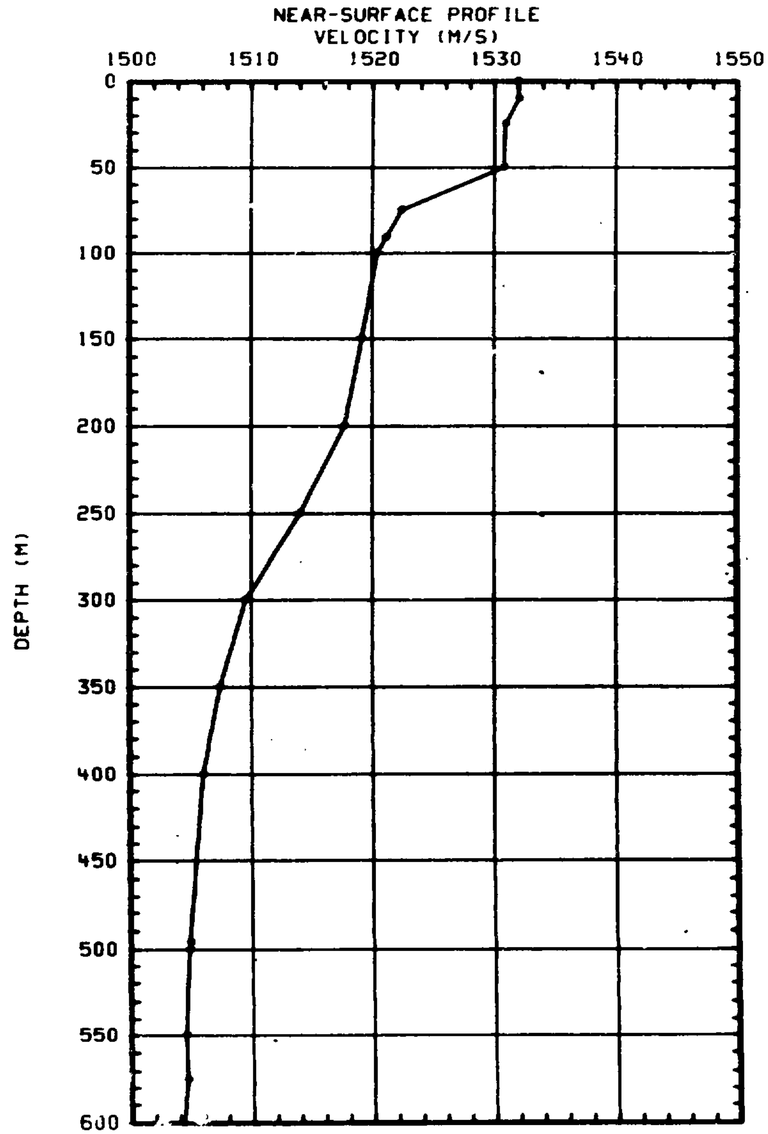
(C) Table IIID-16. Detection Range in km as a Function of Figure of Merit (FOM) in dB for Bearing Stake Data[1] and RAYMODE X Model Results. Case XII: (Station 1B Run P1, Source Depth = 18 m, Receiver Depth = 3350 m, Frequency = 290 Hz.)

Data Set	FOM	R_c[2]	Range $> R_c$
Bearing Stake	75	5.5	
RAYMODE X Coherent	75	-----	ZDC[3] 60%, 1.5-18 km
RAYMODE X Incoherent	75	-- --	100% coverage 1.5-10.5 km
Bearing Stake	80	8.0	ZDC 80%, 8-19 km
RAYMODE X Coherent	80	-----	ZDC 70%, 1.5-19 km
RAYMODE X Incoherent	80	-----	100% coverage 1.5-18 km
Bearing Stake	85	13.5	100% coverage 16-19 km
RAYMODE X Coherent	85	-----	100% coverage, 1.5-8 km, 9-24 km, 30-34.5 km, 36-37.5 km, and 45-52 km, 52.5-55 km
RAYMODE X Incoherent	85	-----	100% coverage 1.5-20 km
Bearing Stake	90	14.0	ZDC 45%, 14-58 km
RAYMODE X Coherent	90	-----	100% coverage 1.5-25.5 km (except dropout at 9 km), 28.5-39 km, 43.5-55.5 km, 57-59 km; ZDC 55%, 76-82.5
RAYMODE X Incoherent	90	-----	100% coverage 1.5-55 km
Bearing Stake	95	24.0	ZDC 75%, 24-63 km; ZDC 40%, 63-112 km
RAYMODE X Coherent	95	-----	100% coverage 1.5-26 km, 28.5-63 km (except dropout at 40.5 km) and 73.5-91.5 km, 116-118.5 km
RAYMODE X Incoherent	95	-----	100% coverage 1.0-63 km, 79.5-88 km
Bearing Stake	100	36.5	ZDC 85%, 36.5-134 km; ZDC 15%, 134-222 km
RAYMODE X Coherent	100	-----	100% coverage 1.5-26 km, 28-66 km, 73-94 km, 101-105 km, 106.5-124.5 km, with peak at 70.5 km
RAYMODE X Incoherent	100	97.5	
Bearing Stake	105	134.0	ZDC 70%, 134-286 km
RAYMODE X Coherent	105	-----	100% coverage 1.0-67.5 km, 70-71.5 km, 72-95 km, and 97-129 km; ZDC 65%, 130.5-167 km; ZDC 5%, 170-192 km
RAYMODE X Incoherent	105	136.5	
Bearing Stake	110	257.0	ZDC 85%, 257-286 km
RAYMODE X Coherent	110	96.0	100% coverage 97-132 km, 133.5-195 km; ZDC 55%, 196.5-228 km
RAYMODE X Incoherent	110	177.0	

1. Smoothed by running average with 2 kilometer window.
2. R_c = Range to which detection coverage is continuous.
3. ZDC = Zonal Detection Coverage in percentage of indicated range interval over which detection can be made.

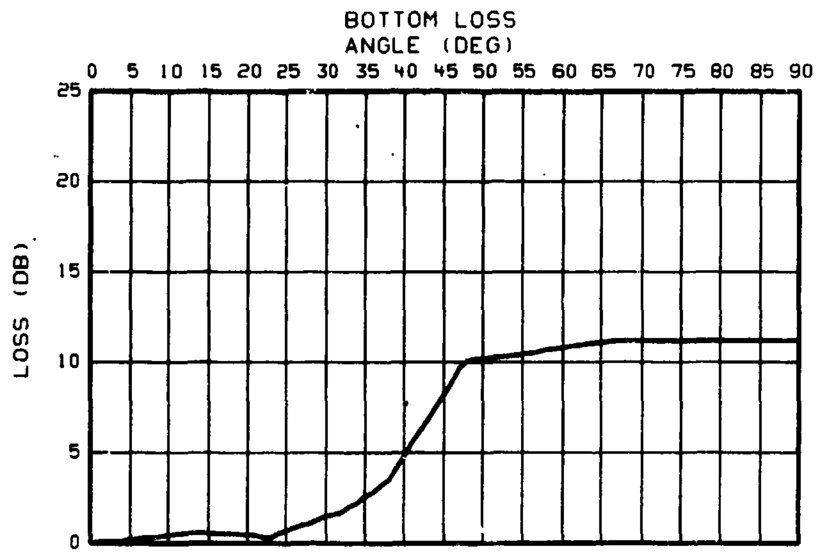


DEPTH	VELOCITY
0.0	1531.90
10.0	1532.00
25.0	1530.90
50.0	1530.80
75.0	1522.[illegible]
91.0	1521.[illegible]
100.0	1520.40
150.0	1519.10
200.0	1517.70
250.0	1514.00
300.0	1509.50
350.0	1507.40
400.0	1506.00
496.0	1504.85
500.0	1504.80
550.0	1504.50
575.0	1504.60
625.0	1504.00
675.0	1503.60
700.0	1503.70
800.0	1502.60
900.0	1501.90
1000.0	1500.50
1100.0	1499.10
1200.0	1498.60
1300.0	1457.70
1400.0	1496.80
1500.0	1495.90
1600.0	1495.30
1725.0	1495.00
1800.0	1495.30
1901.0	1495.20
2000.0	1495.70
2200.0	1497.20
2500.0	1500.30
3000.0	1507.70
3350.0	1513.50



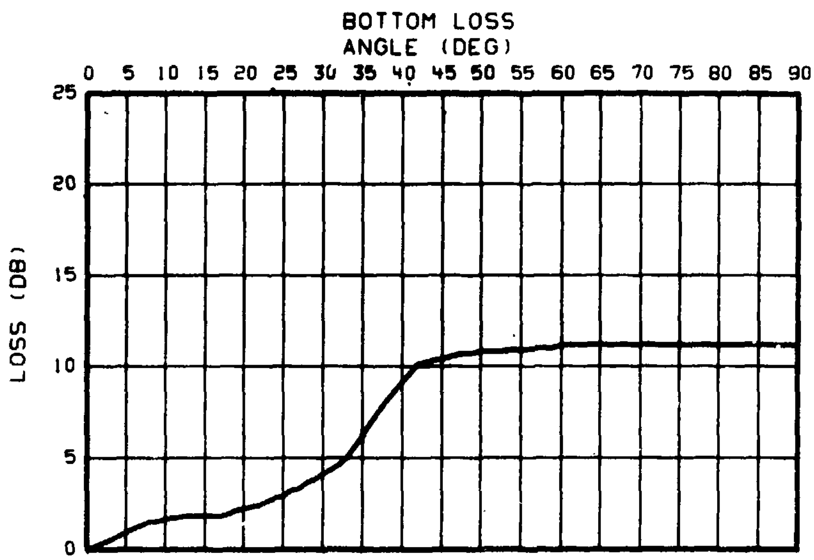
CONFIDENTIAL

(U) Figure IIID-1. Bearing Stake Sound Speed Profile Station 1B, Run P1



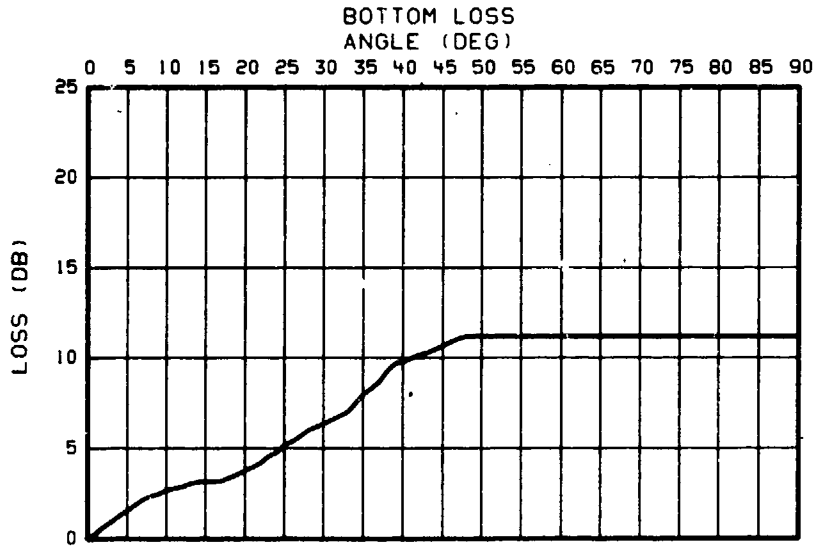
CONFIDENTIAL

(C) Figure IIID-2. Bottom Loss Versus Grazing Angle. Frequency = 25 Hertz



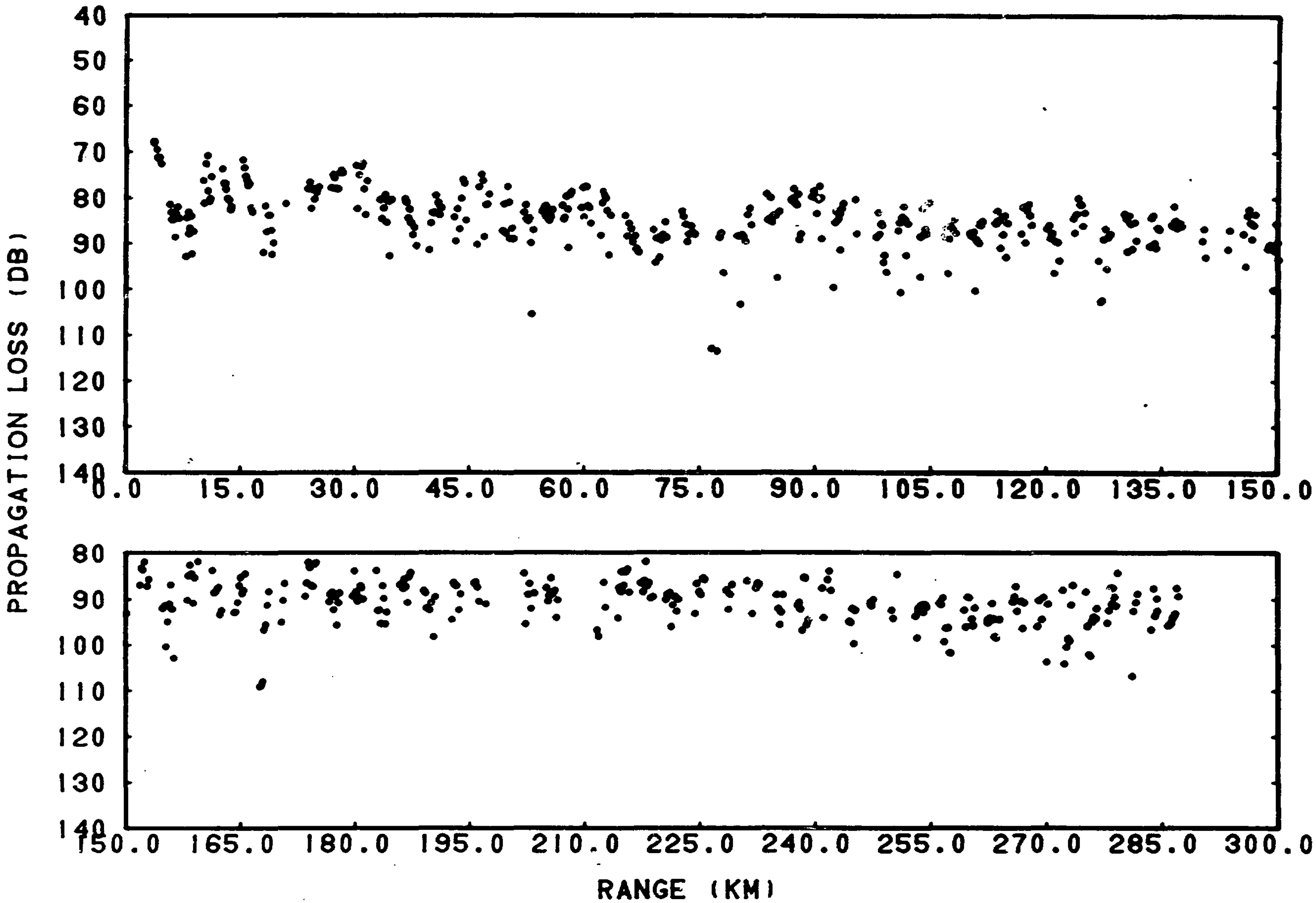
CONFIDENTIAL

(C) Figure IIID-3. Bottom Loss Versus Grazing Angle. Frequency = 140 Hertz



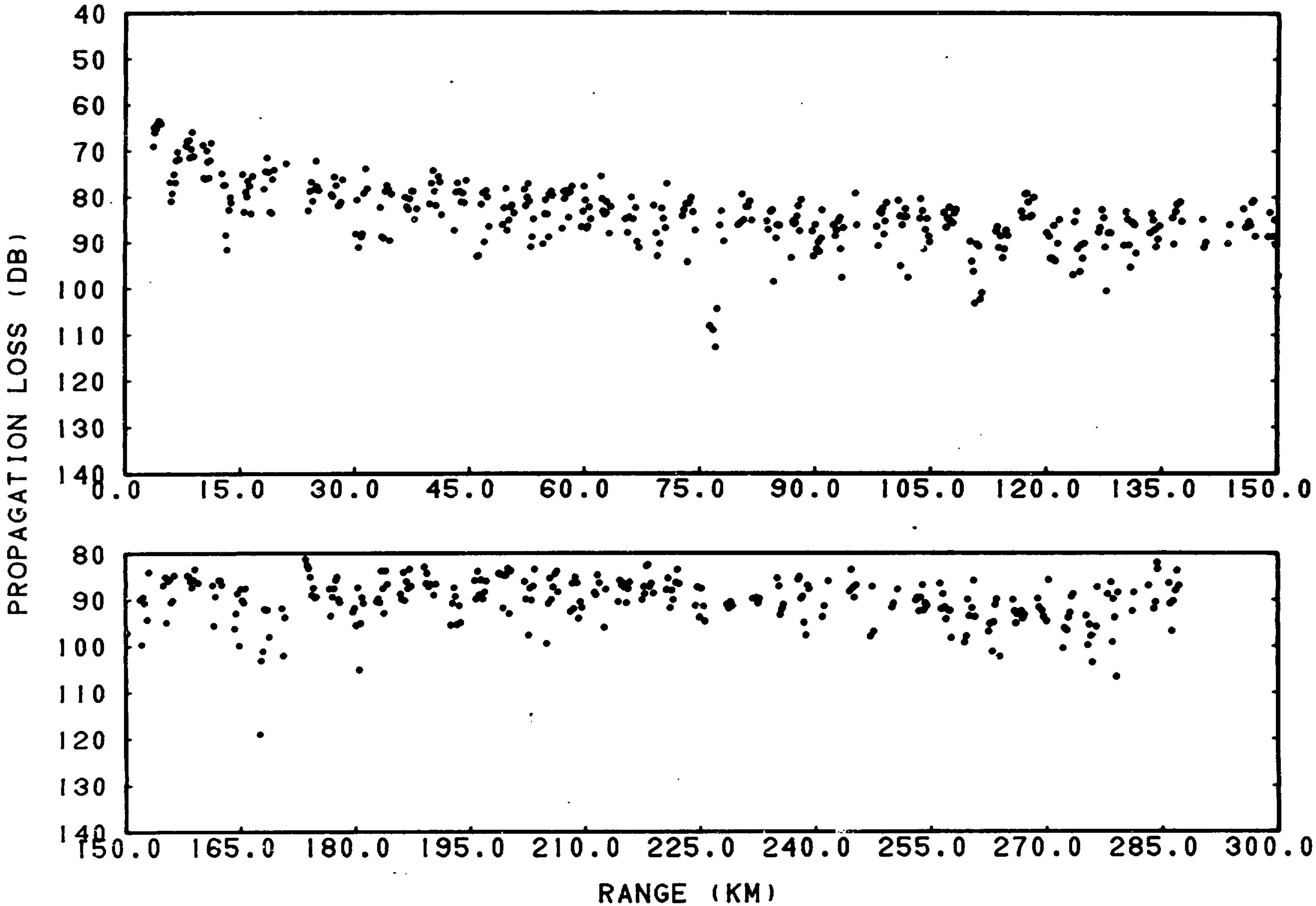
CONFIDENTIAL

(C) Figure IIID-4. Bottom Loss Versus Grazing Angle. Frequency = 290 Hertz



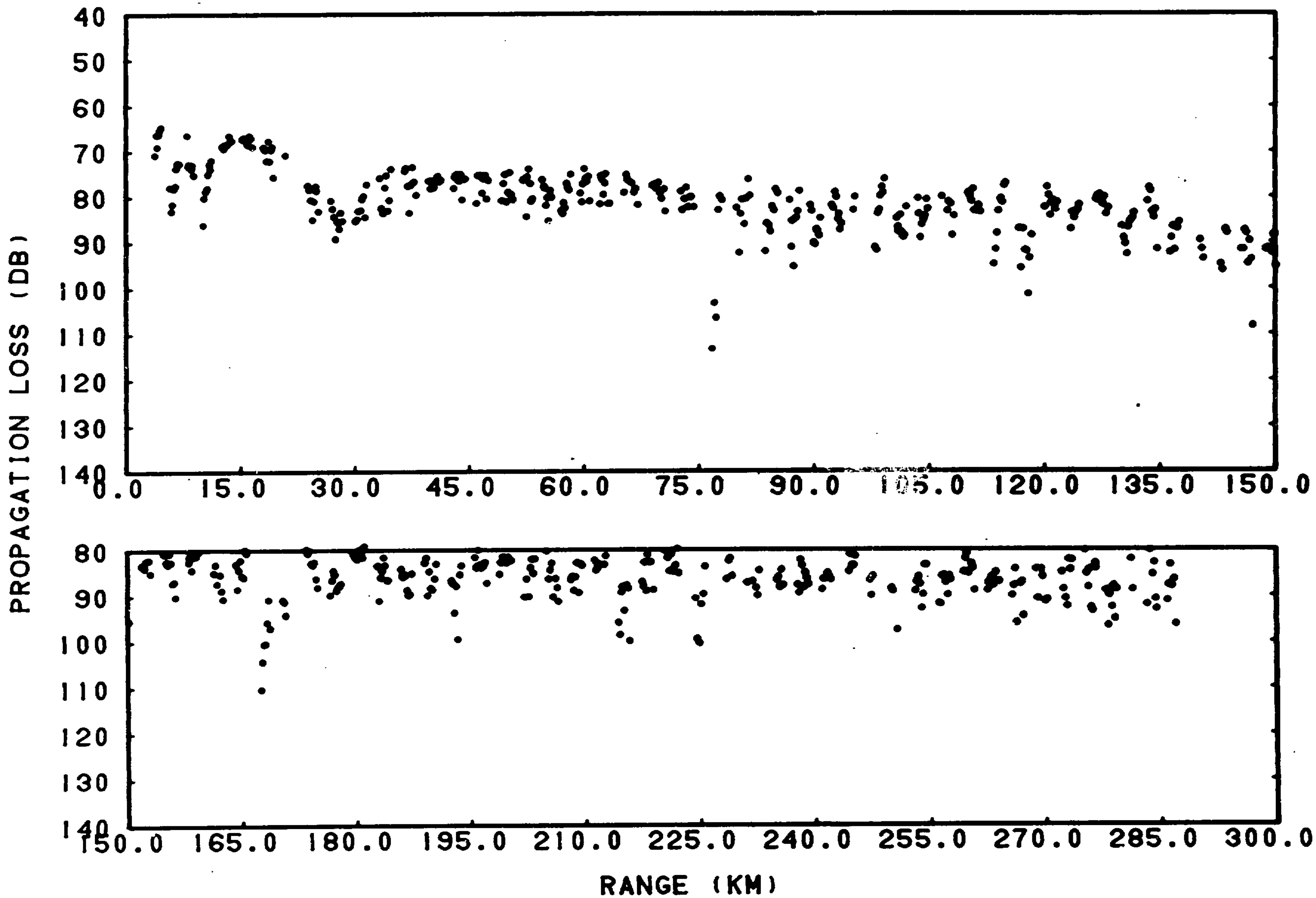
CONFIDENTIAL

(C) Figure IIID-5. Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 496 Meters, Frequency = 25 Hertz



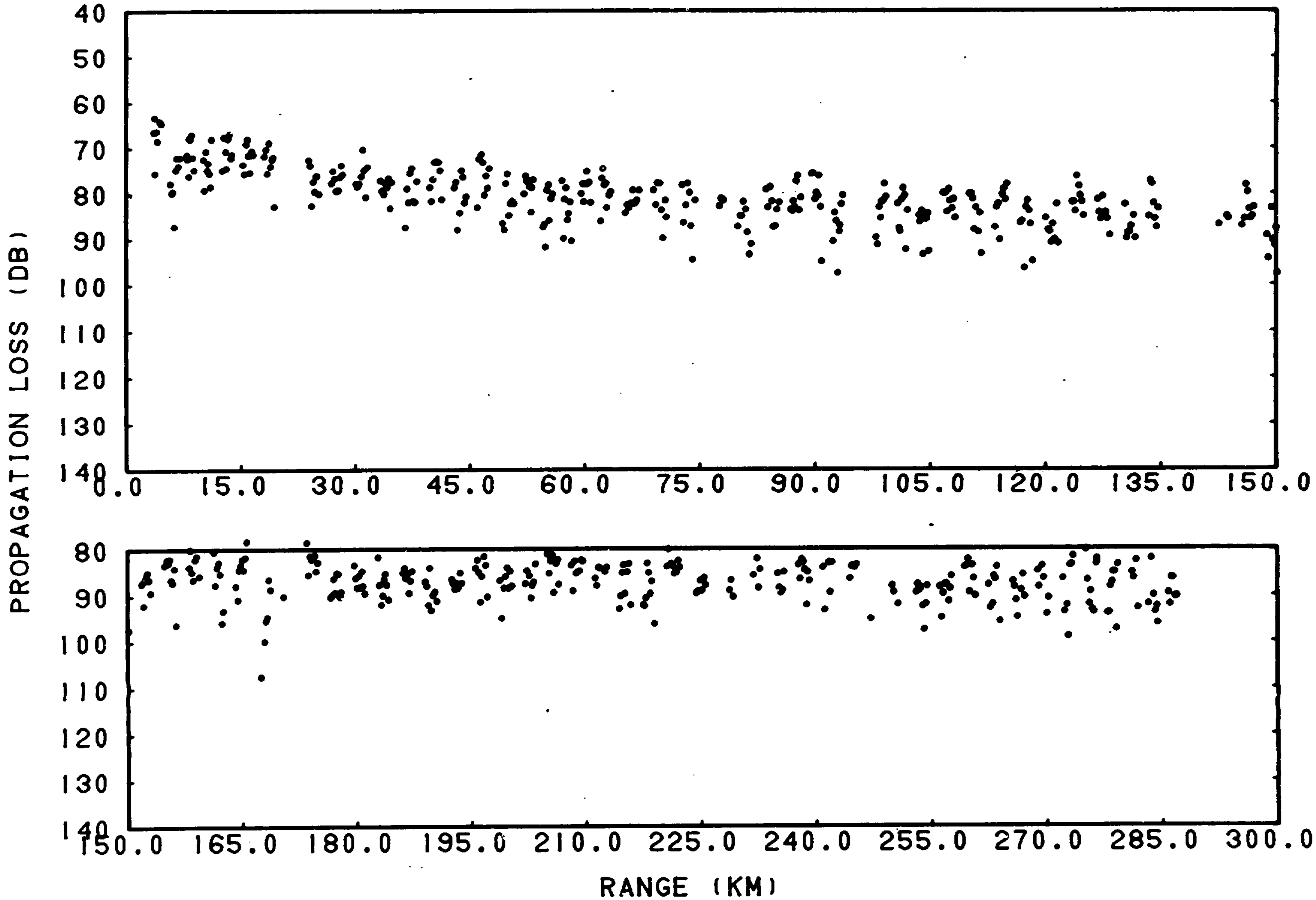
CONFIDENTIAL

(C) Figure IIID-6. Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 1685 Meters, Frequency = 25 Hertz



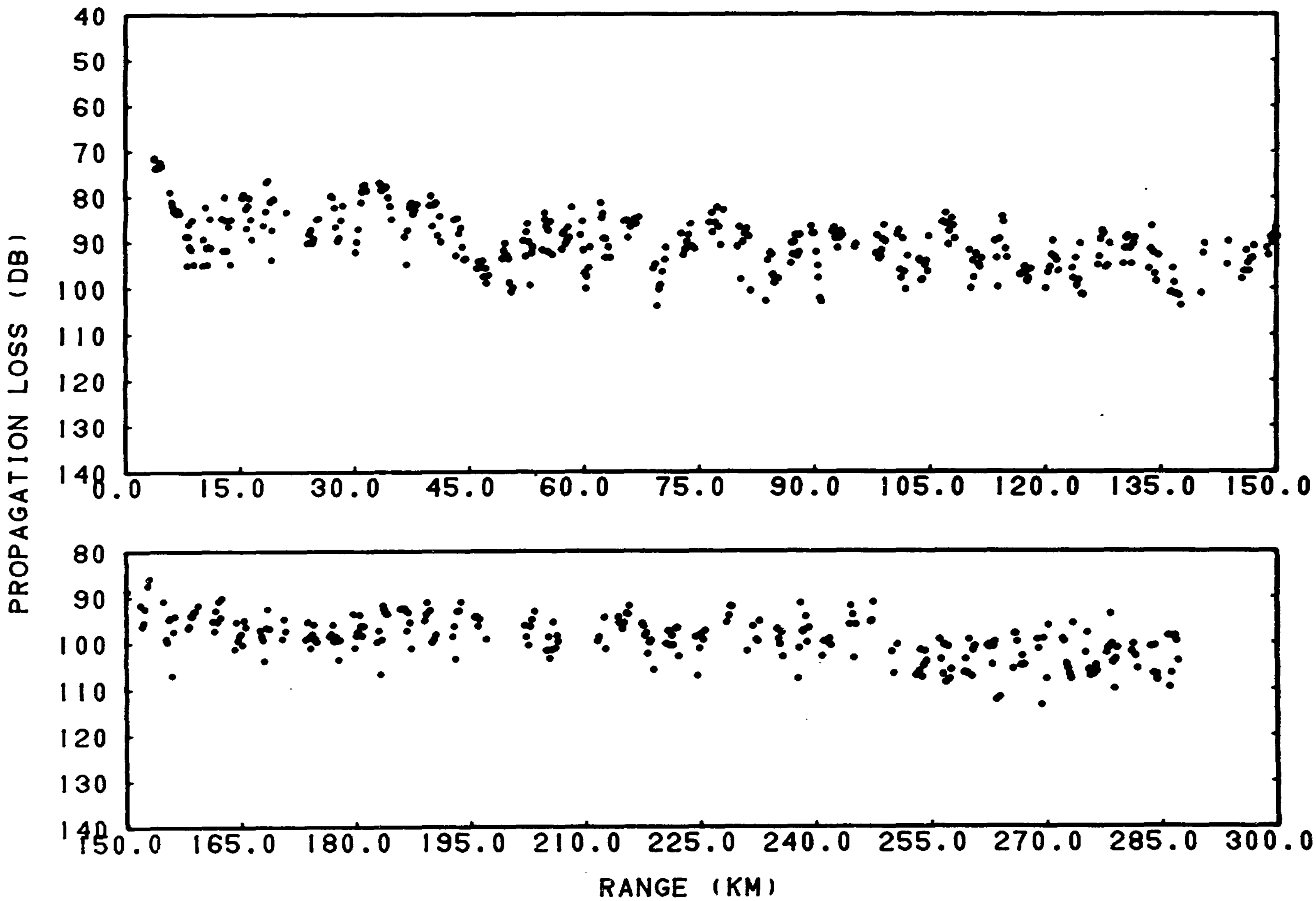
CONFIDENTIAL

(C) Figure IIID-7. Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3320 Meters, Frequency = 25 Hertz



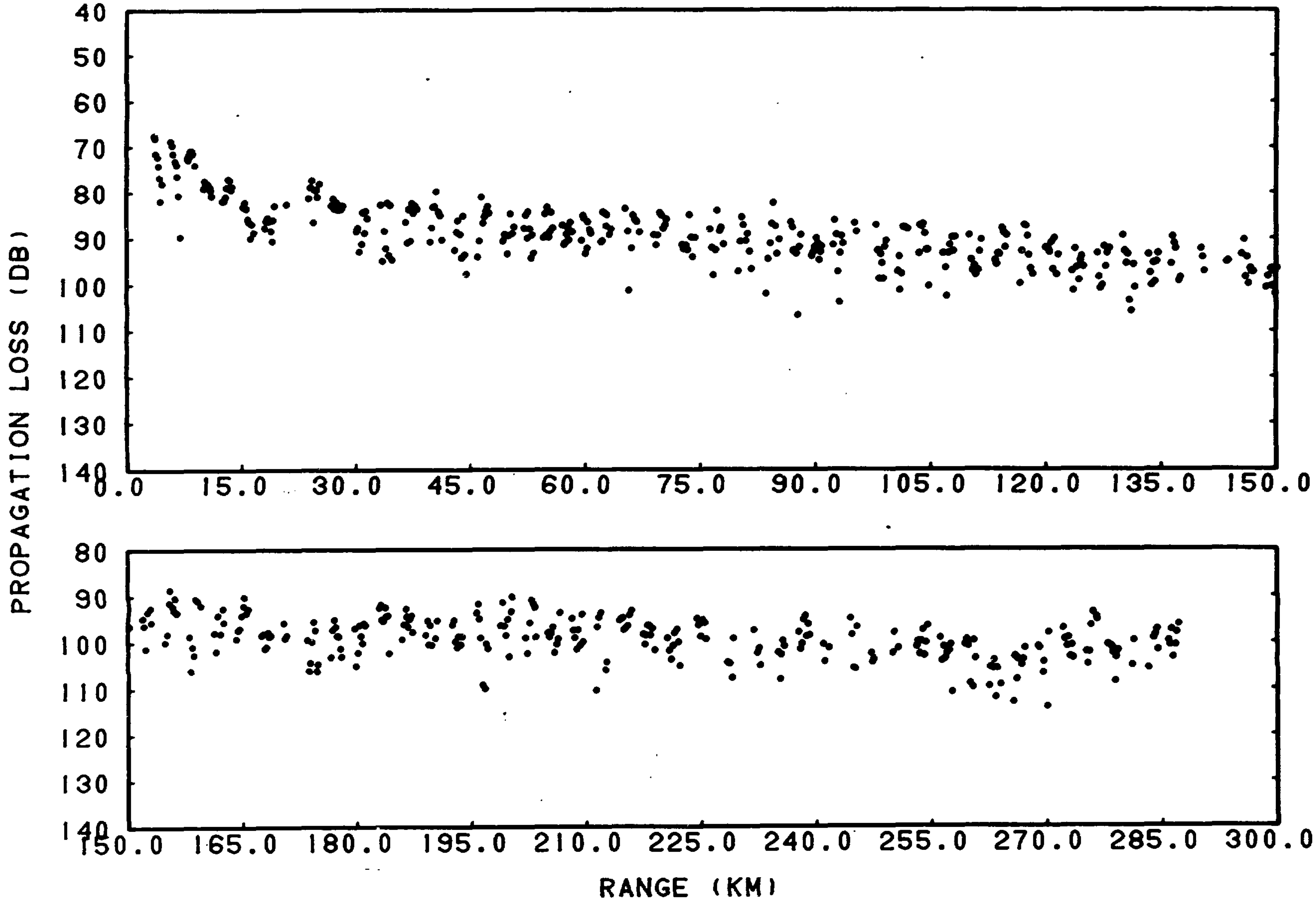
CONFIDENTIAL

(C) Figure IIID-8. Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3350 Meters, Frequency = 25 Hertz



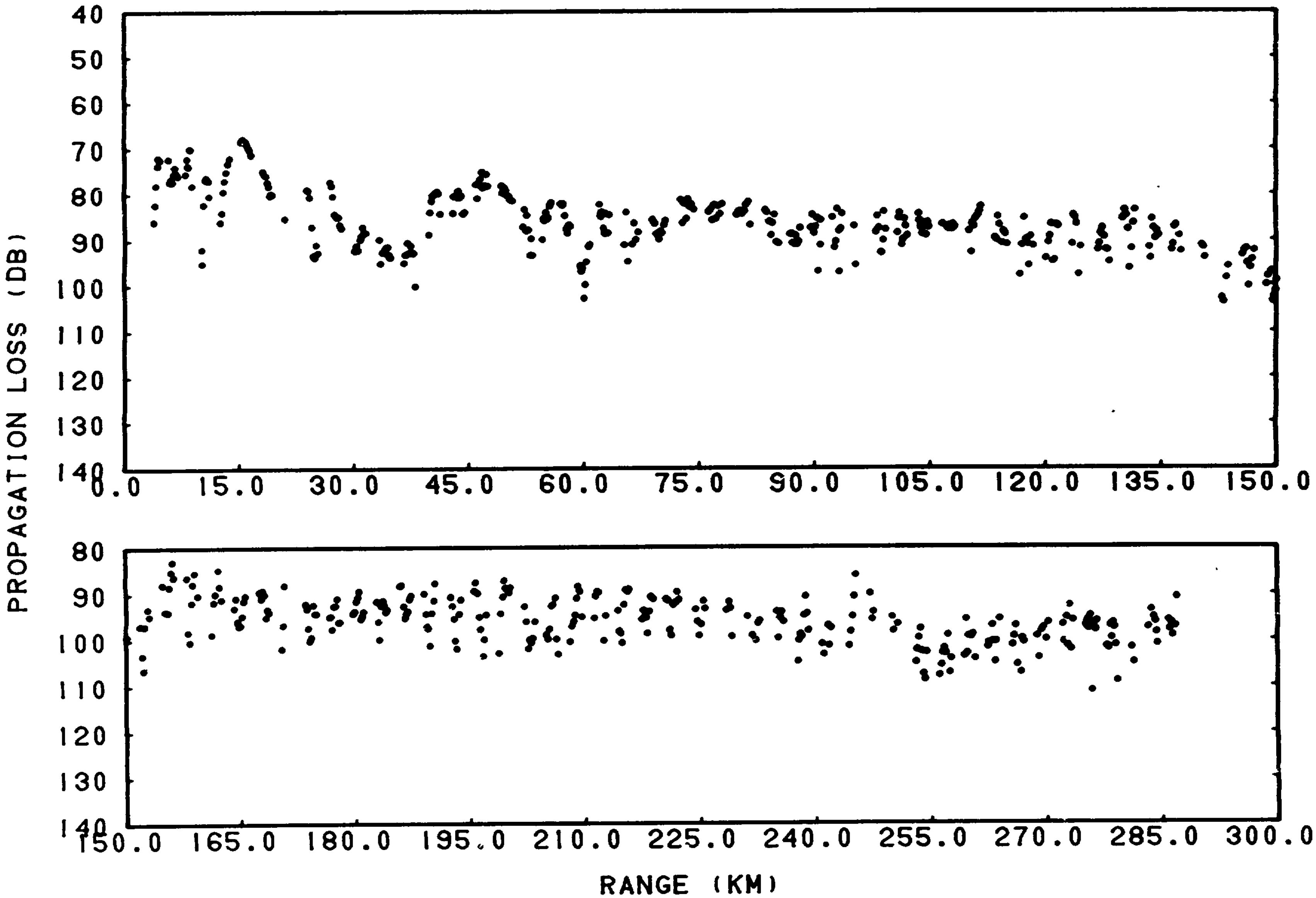
CONFIDENTIAL

(C) Figure IIID-9. Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 496 Meters, Frequency = 140 Hertz



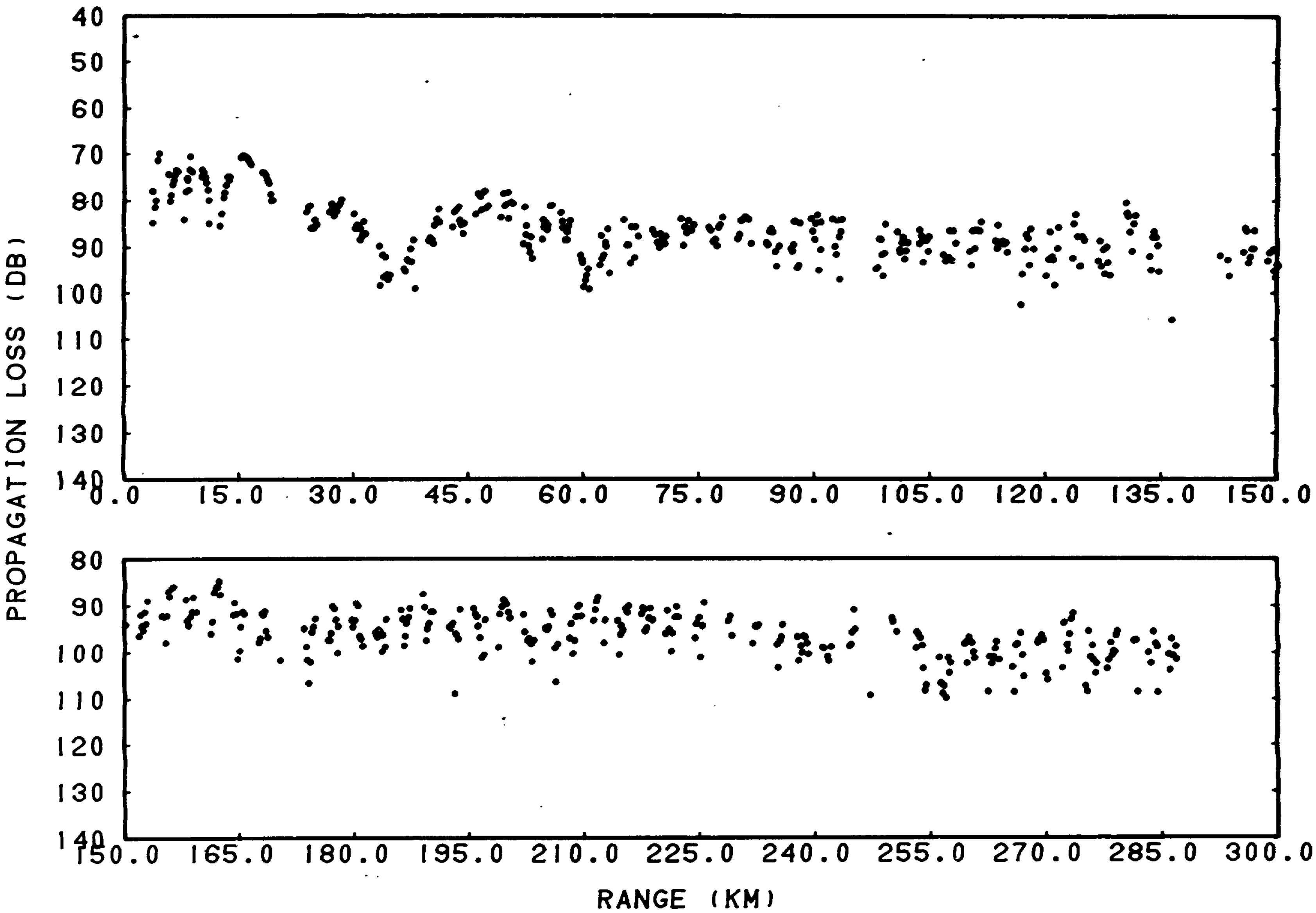
CONFIDENTIAL

(C) Figure IIID-10. Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 140 Hertz



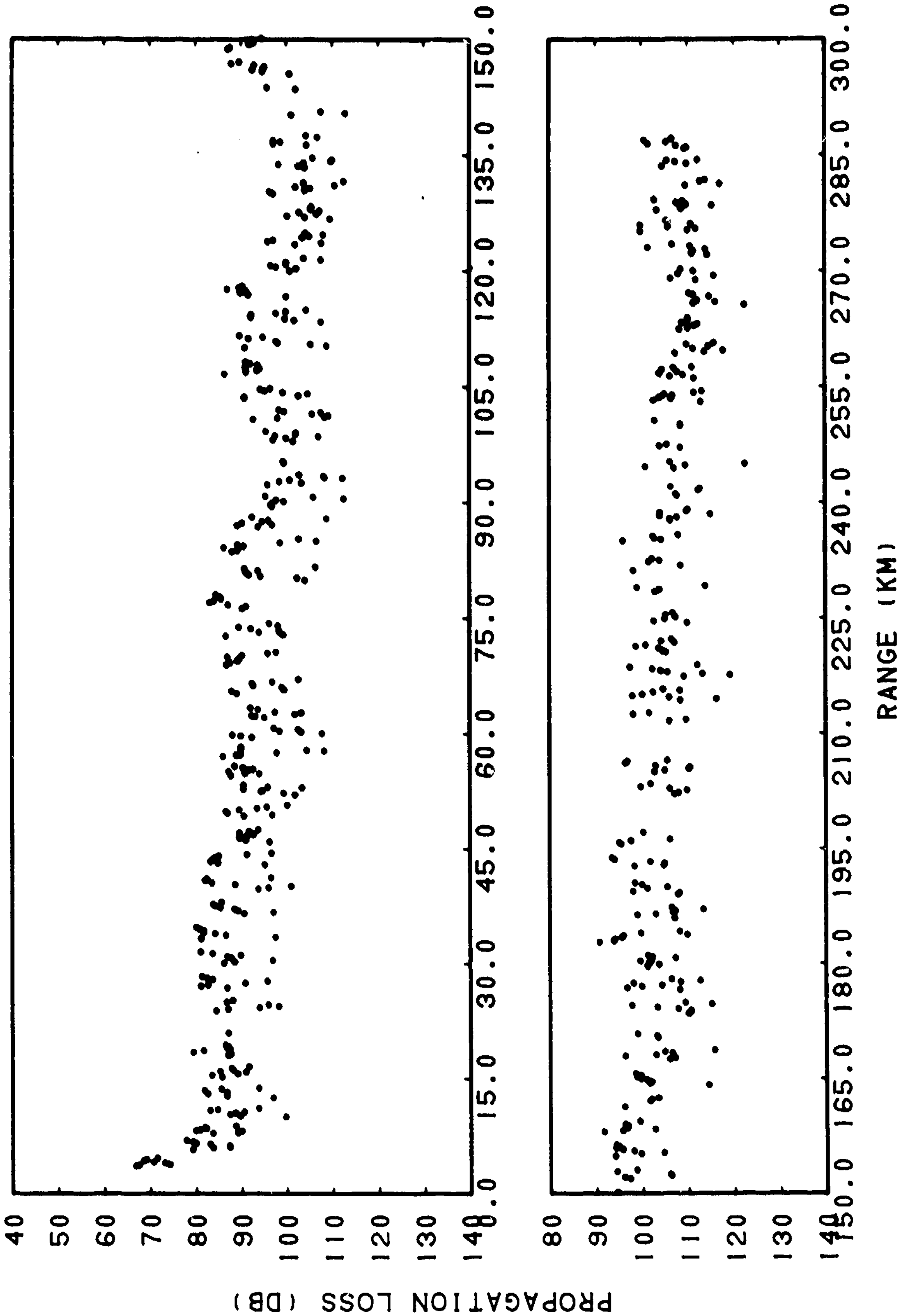
CONFIDENTIAL

(C) Figure IIID-11. Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 140 Hertz



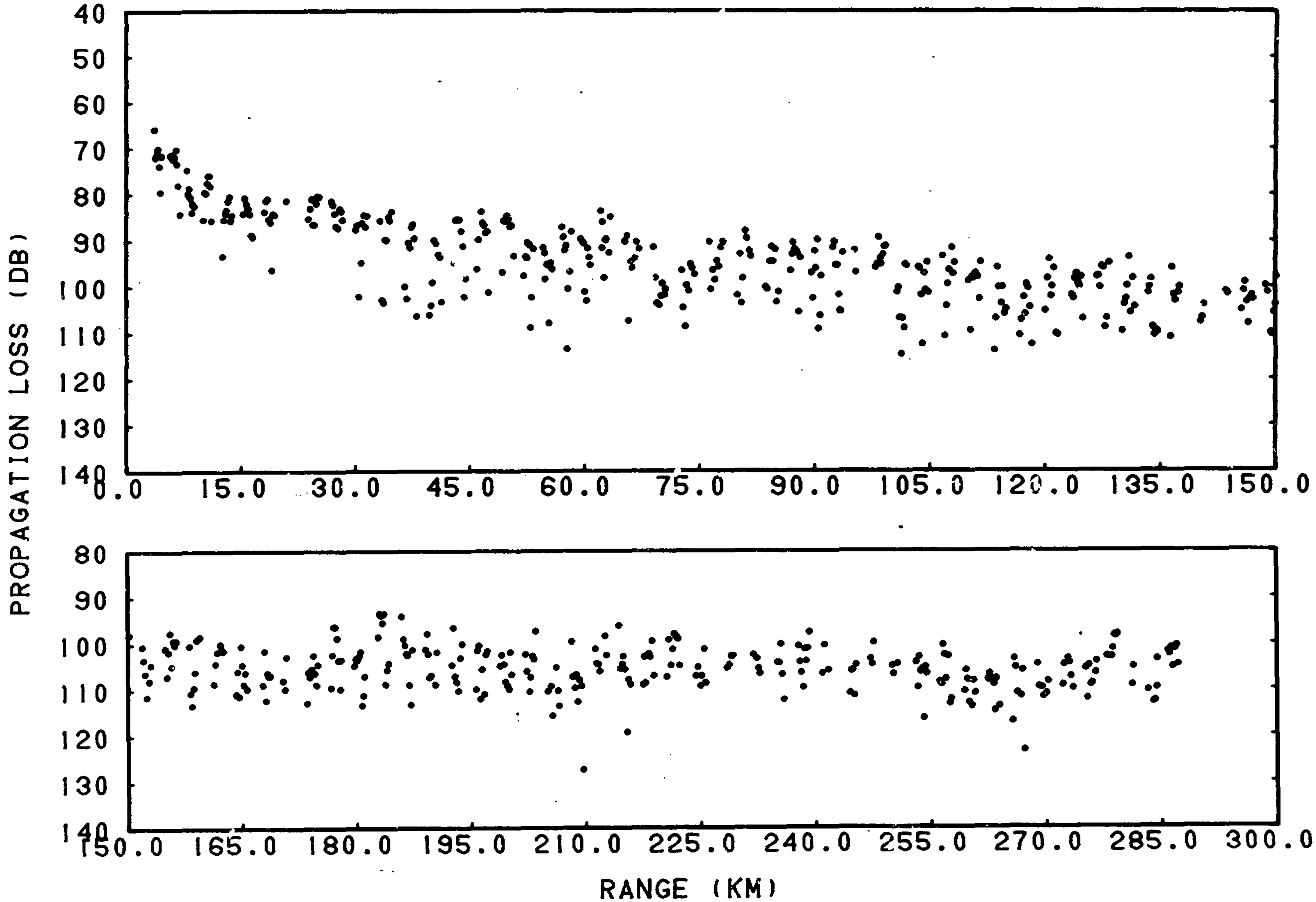
CONFIDENTIAL

(C) Figure IIID-12. Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 140 Hertz



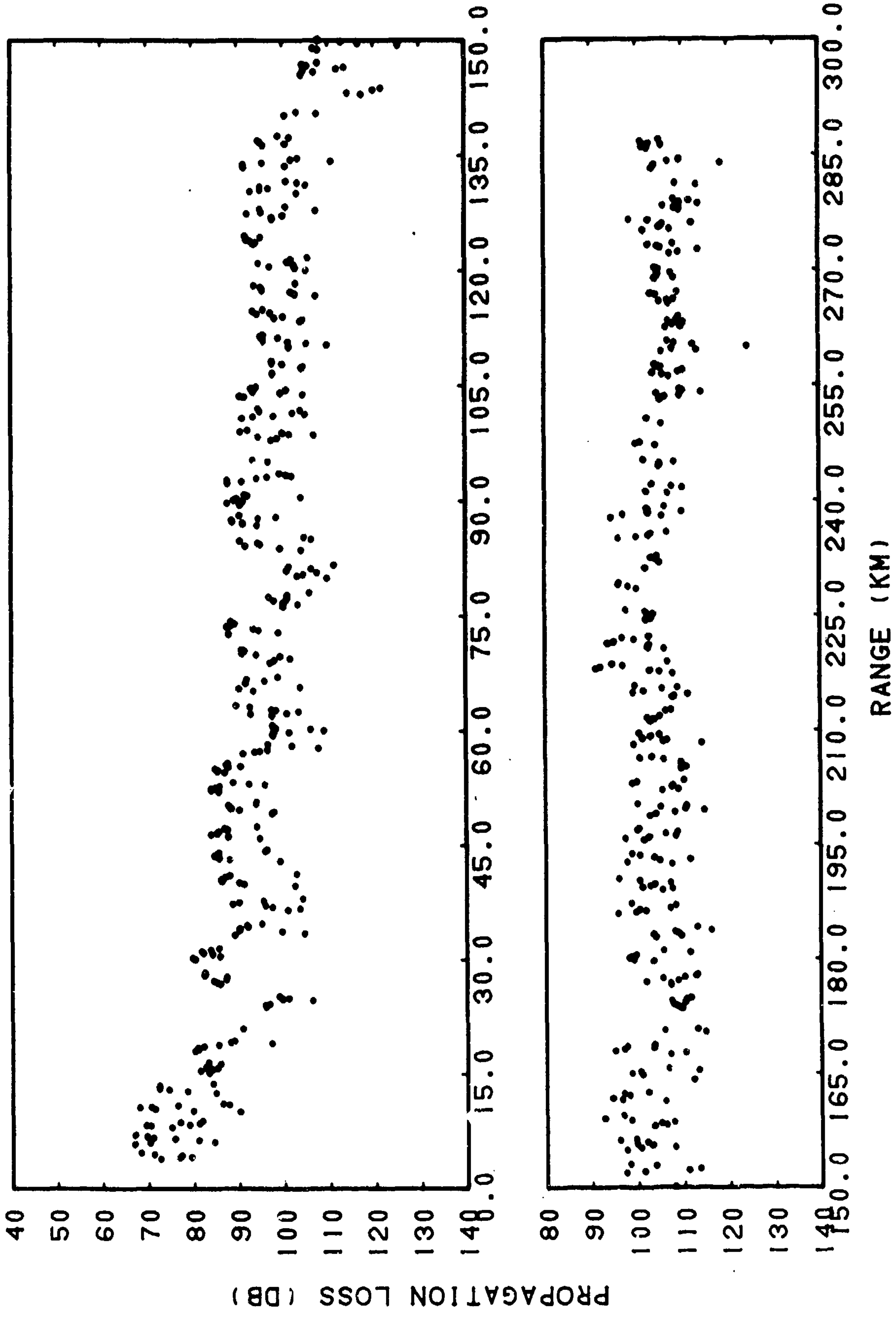
CONFIDENTIAL

(C) Figure IIID-13. Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 290 Hertz



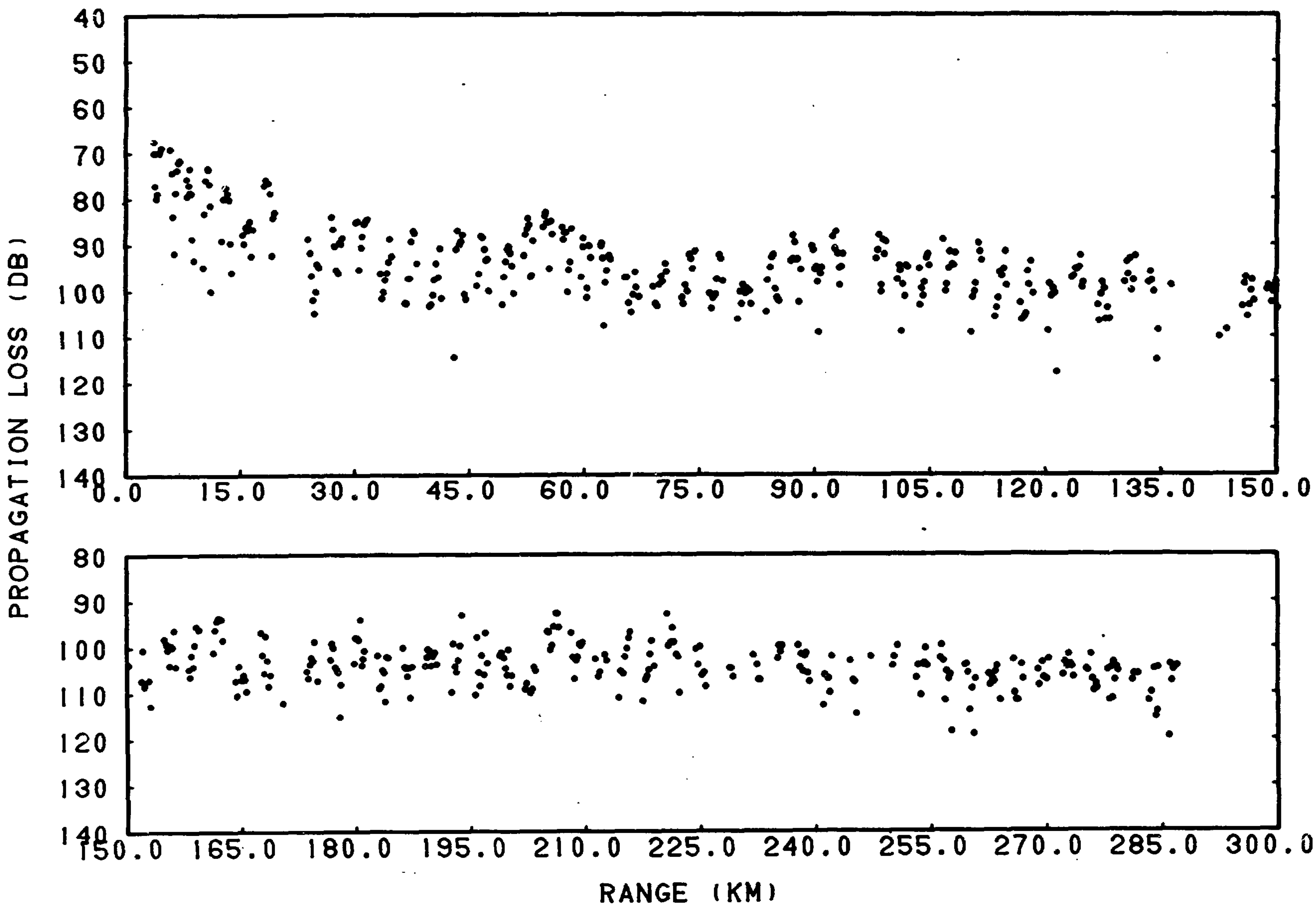
CONFIDENTIAL

(C) Figure IIID-14. Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 290 Hertz



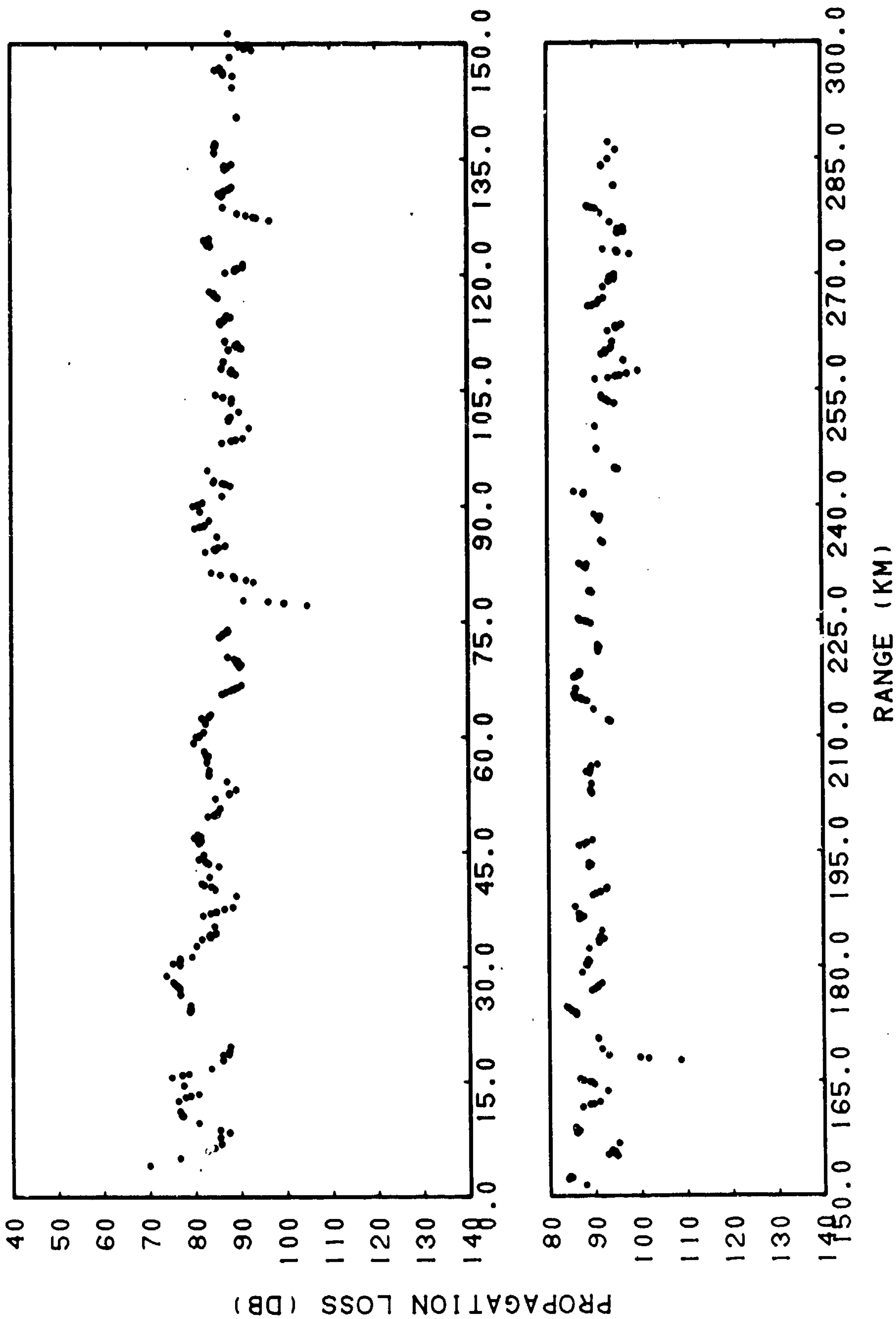
CONFIDENTIAL

(C) Figure IIID-15. Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = [illegible]90 Hertz



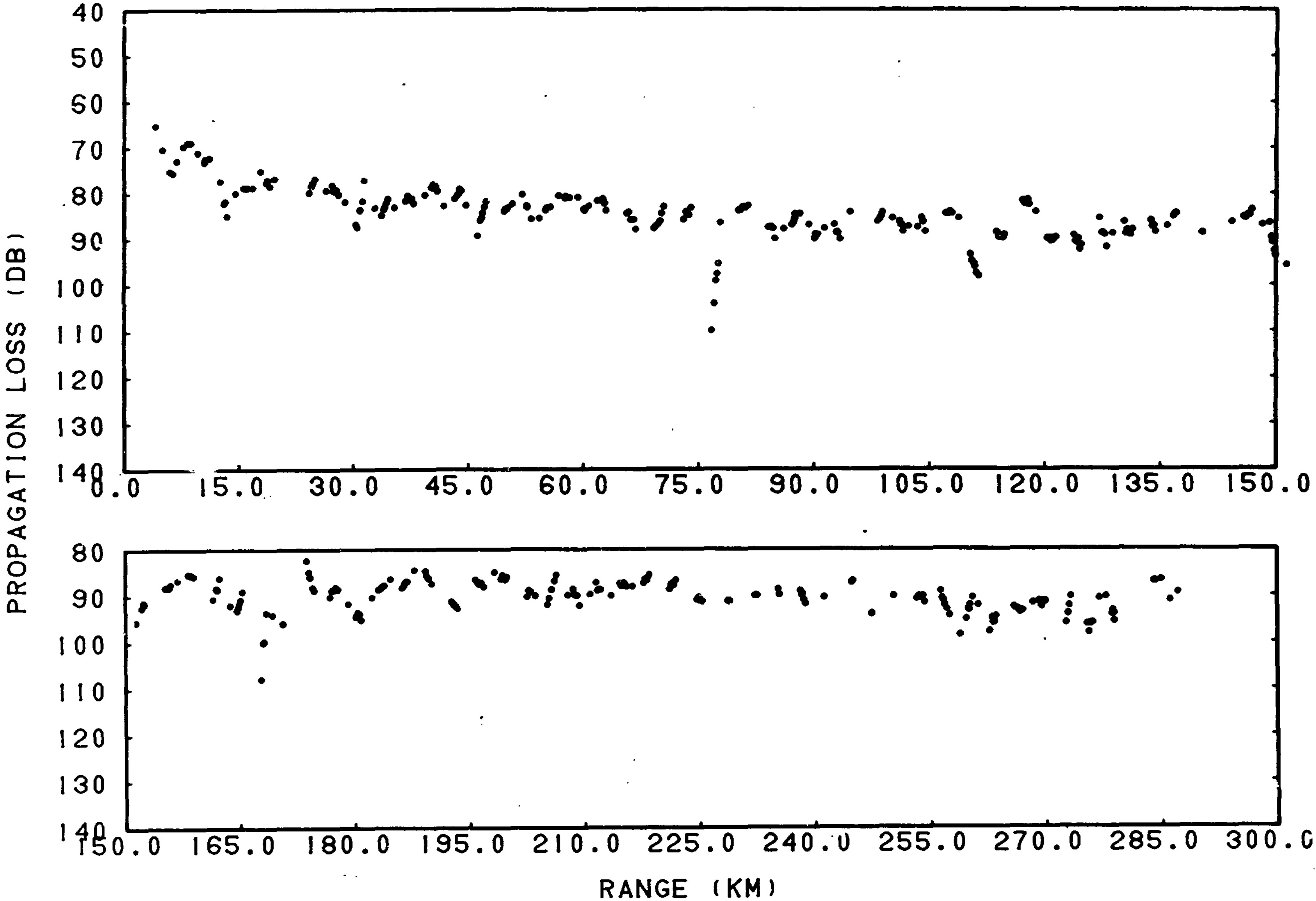
CONFIDENTIAL

(C) Figure IIID-16. Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 290 Hertz



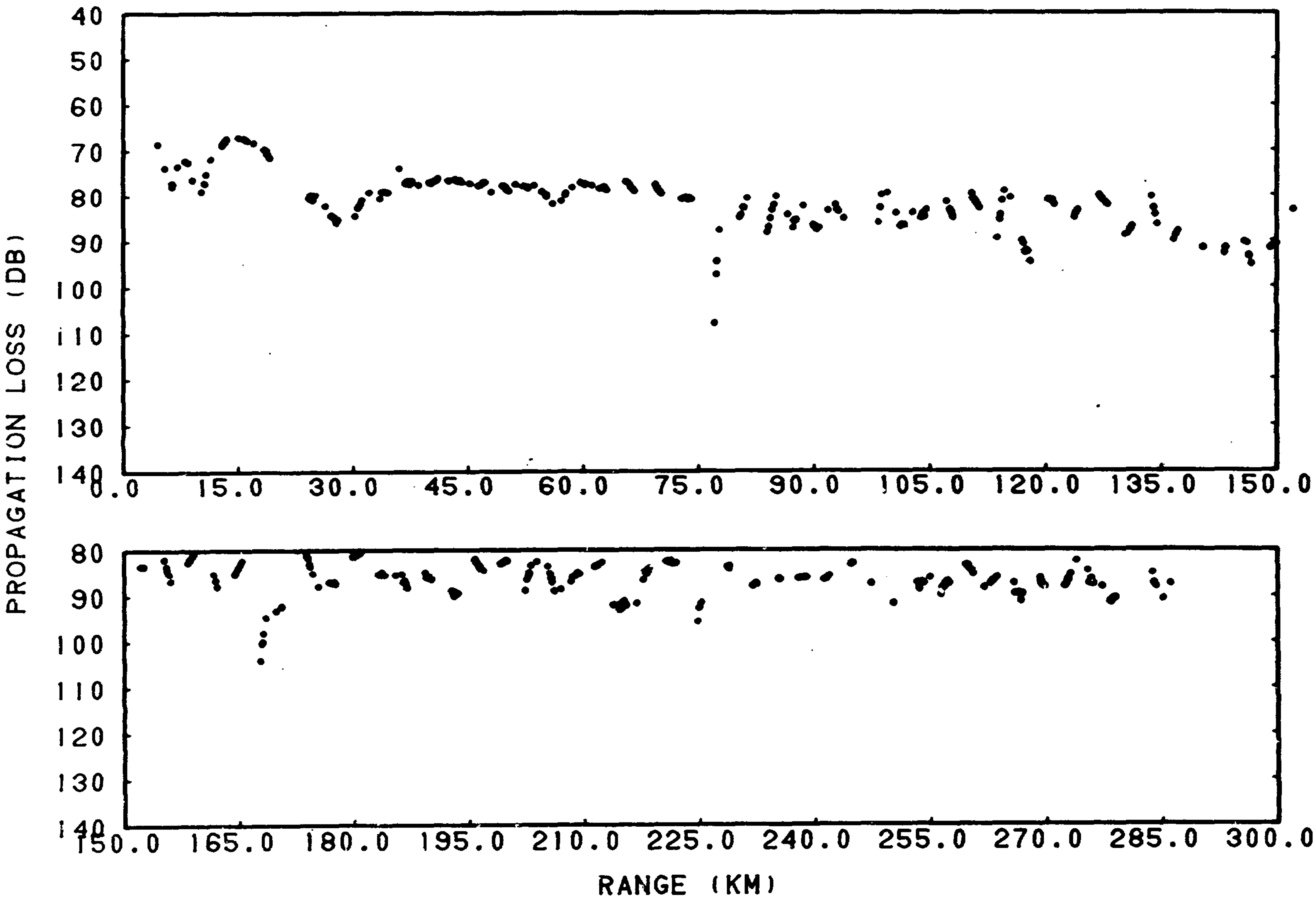
CONFIDENTIAL

(C) Figure IIID-17. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 496 Meters, Frequency = 25 Hertz



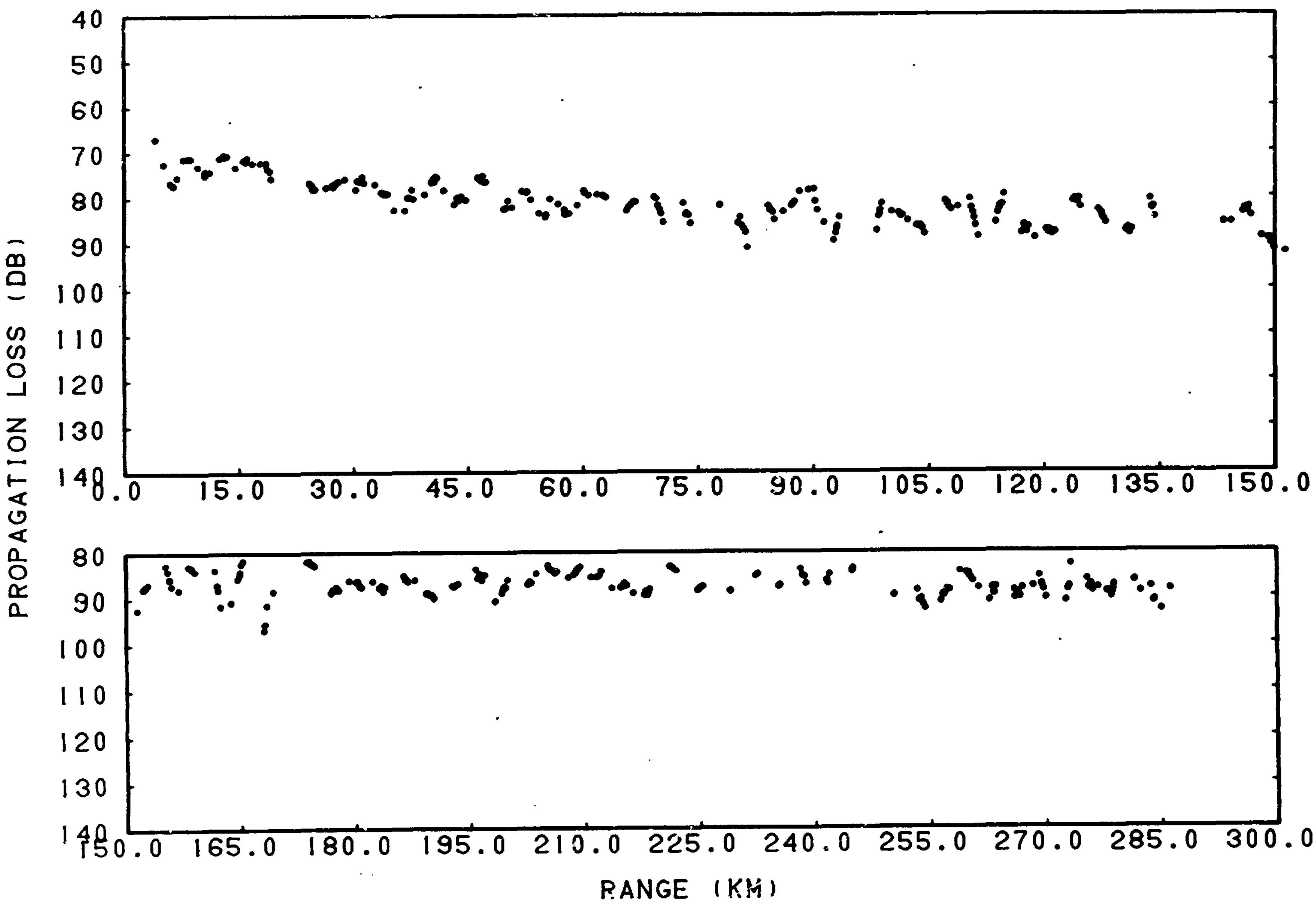
CONFIDENTIAL

(C) Figure IIID-18. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 1685 Meters, Frequency = 25 Hertz



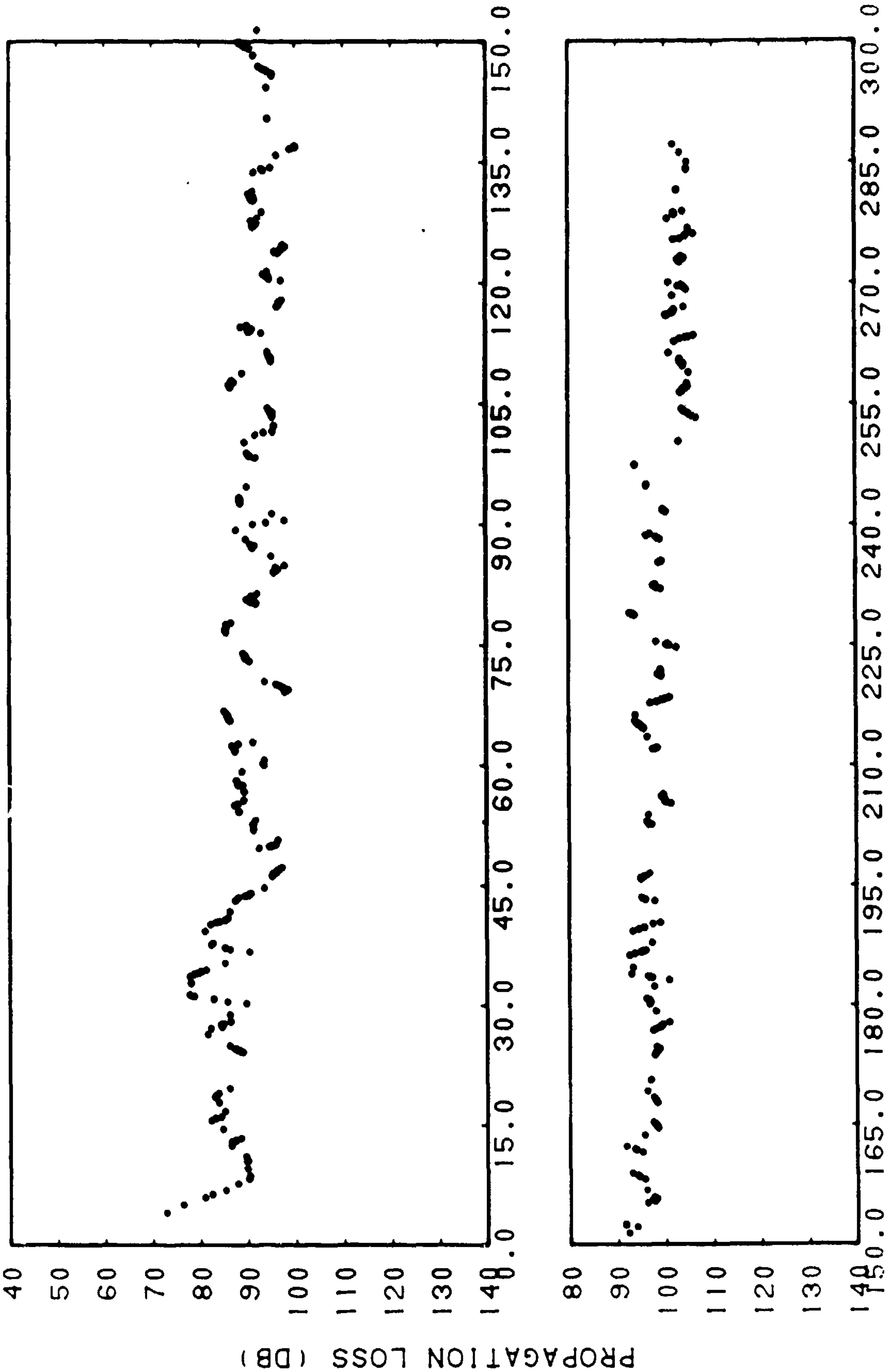
CONFIDENTIAL

(C) Figure IIID-19. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3320 Meters, Frequency = 25 Hertz



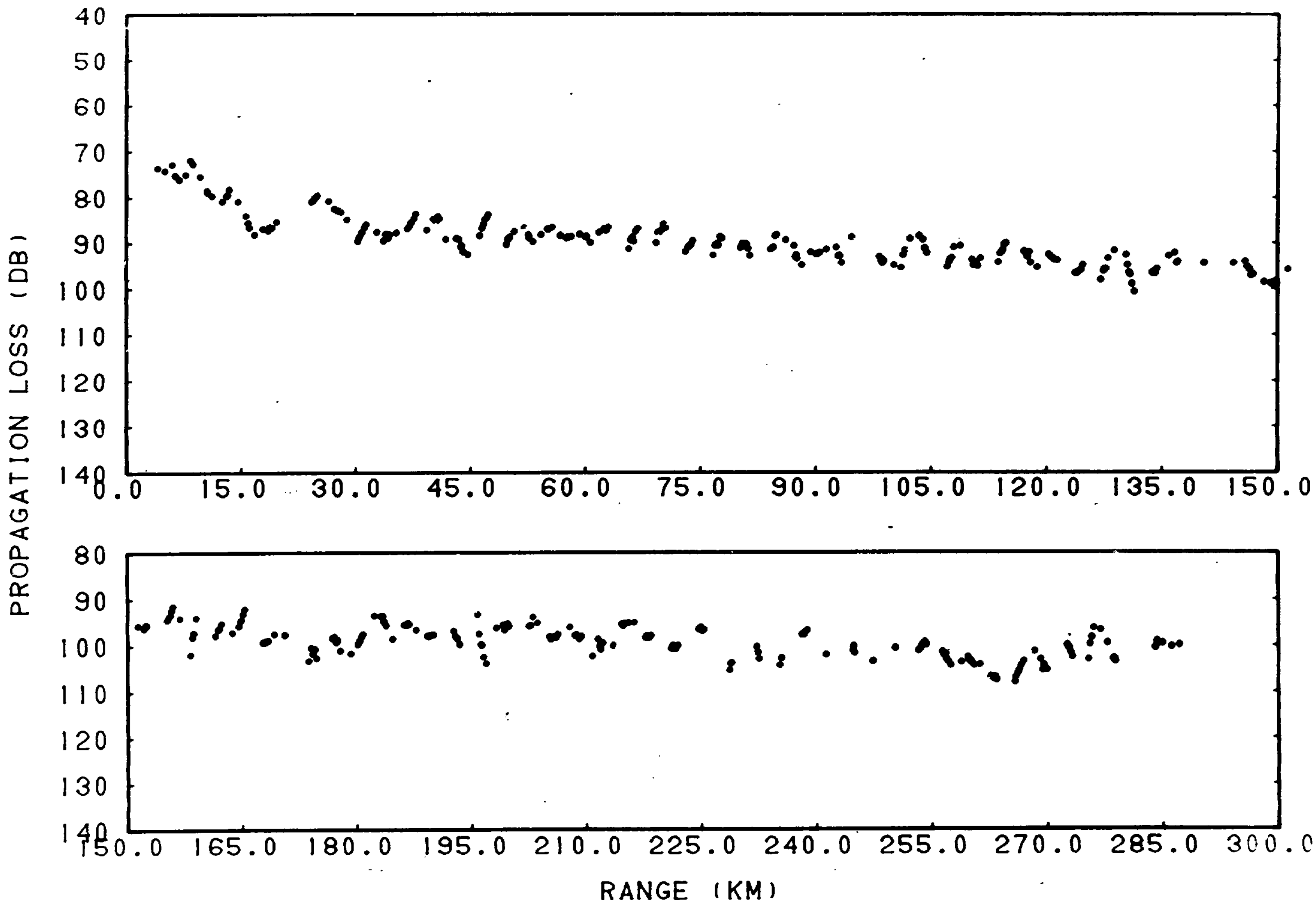
CONFIDENTIAL

(C) Figure IIID-20. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3350 Meters, Frequency = 25 Hertz



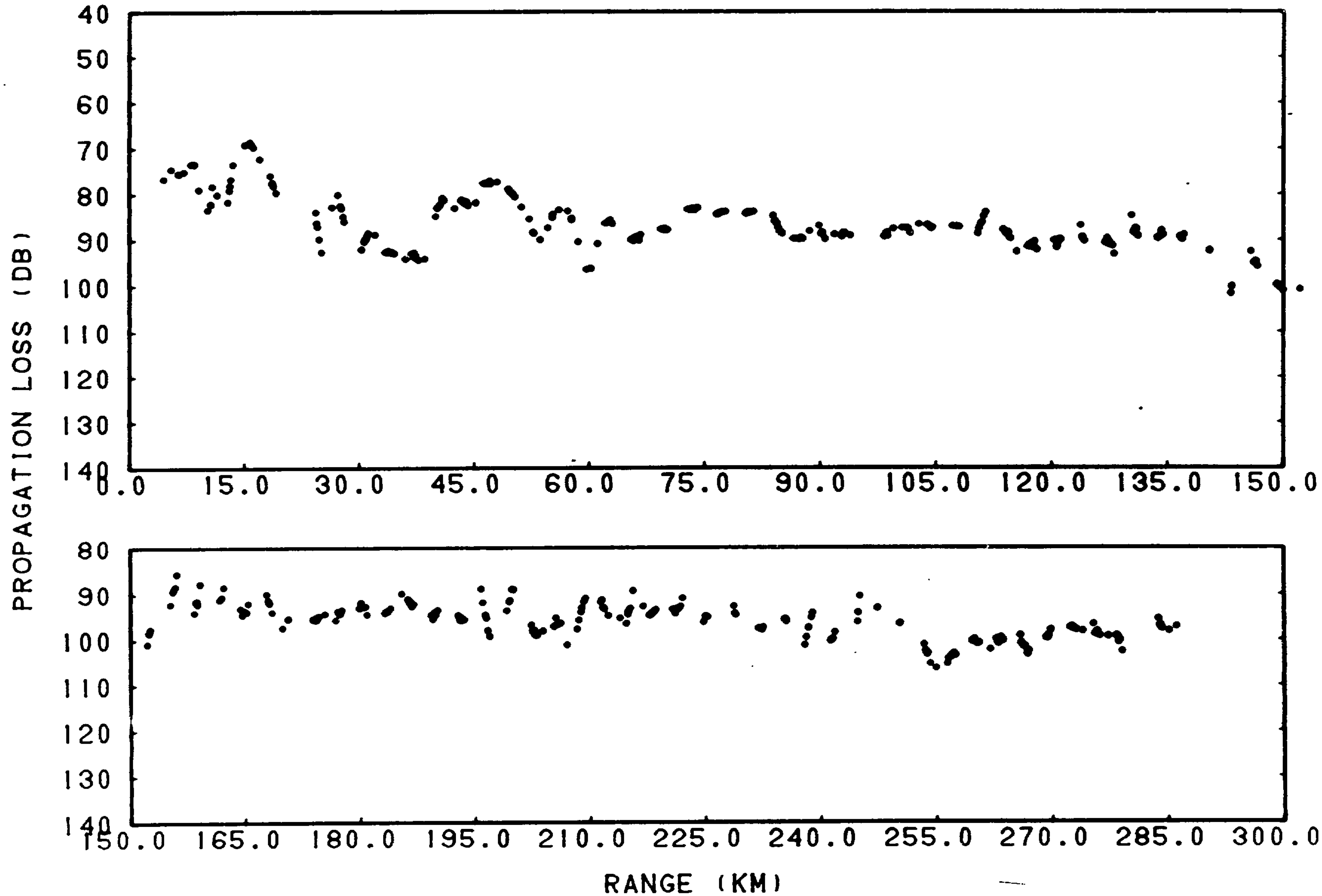
CONFIDENTIAL

(C) Figure IIID 21. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 140 Hertz



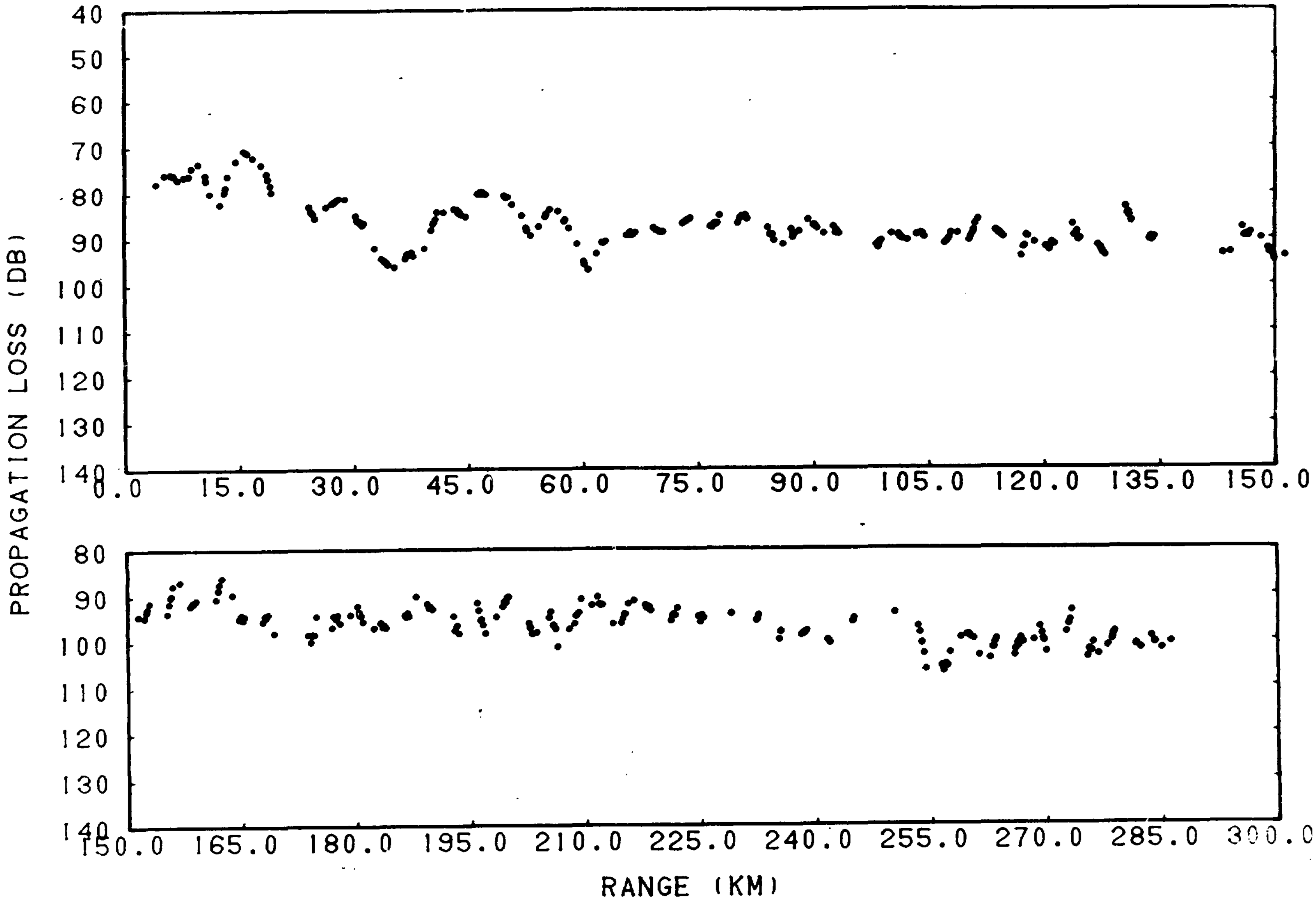
CONFIDENTIAL

(C) Figure IIID-22. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 140 Hertz



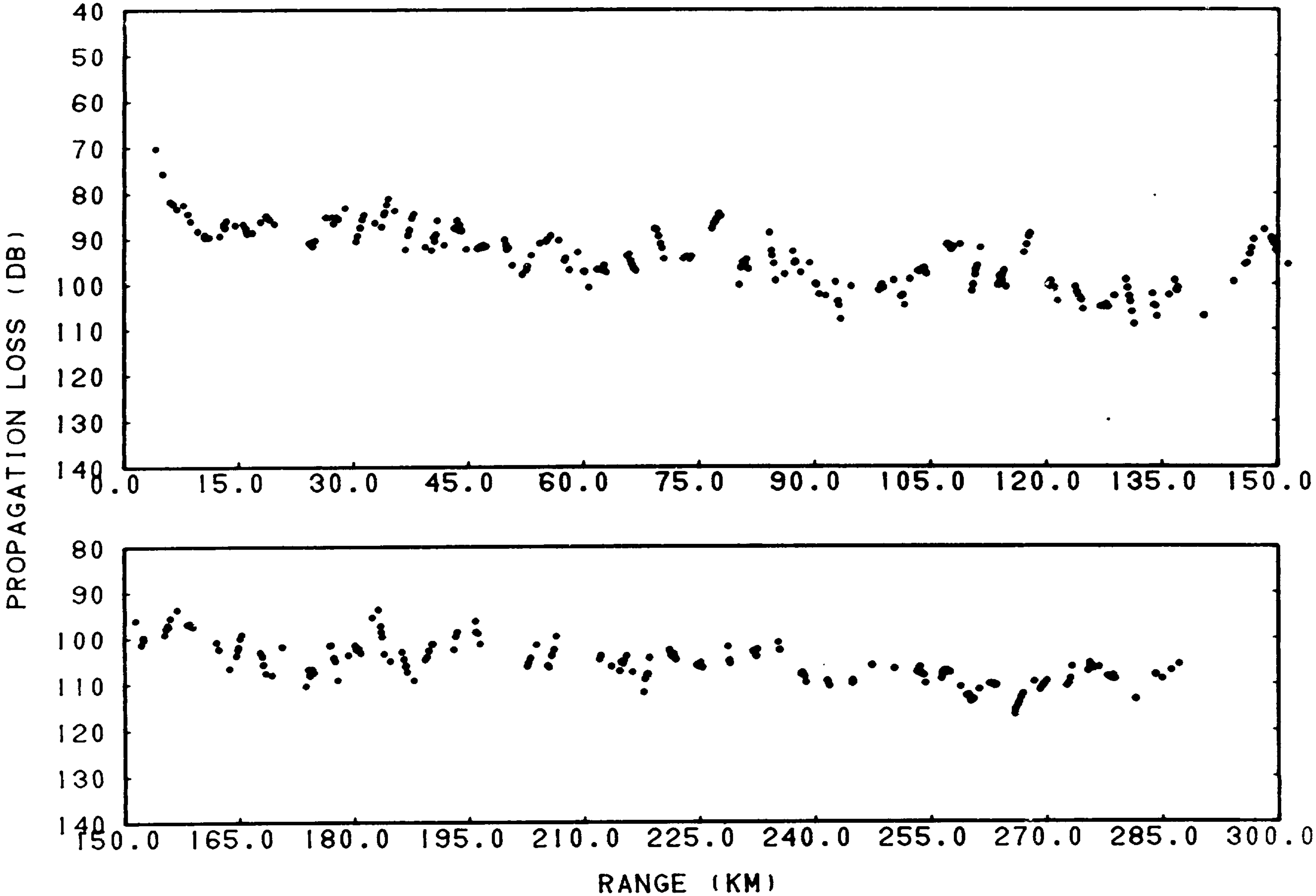
CONFIDENTIAL

(C) Figure IIID-23. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 140 Hertz



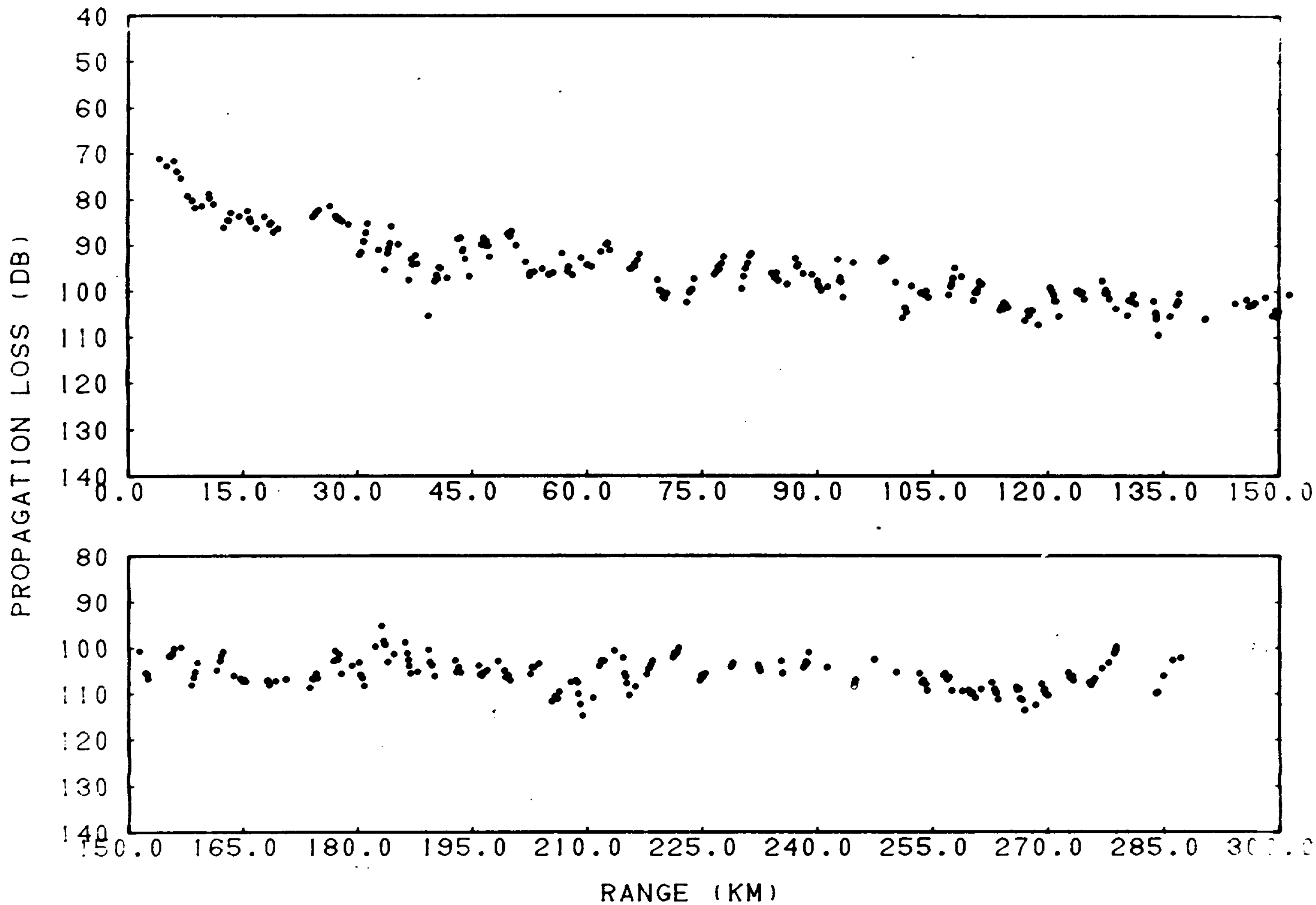
CONFIDENTIAL

(C) Figure IIID-24. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 140 Hertz



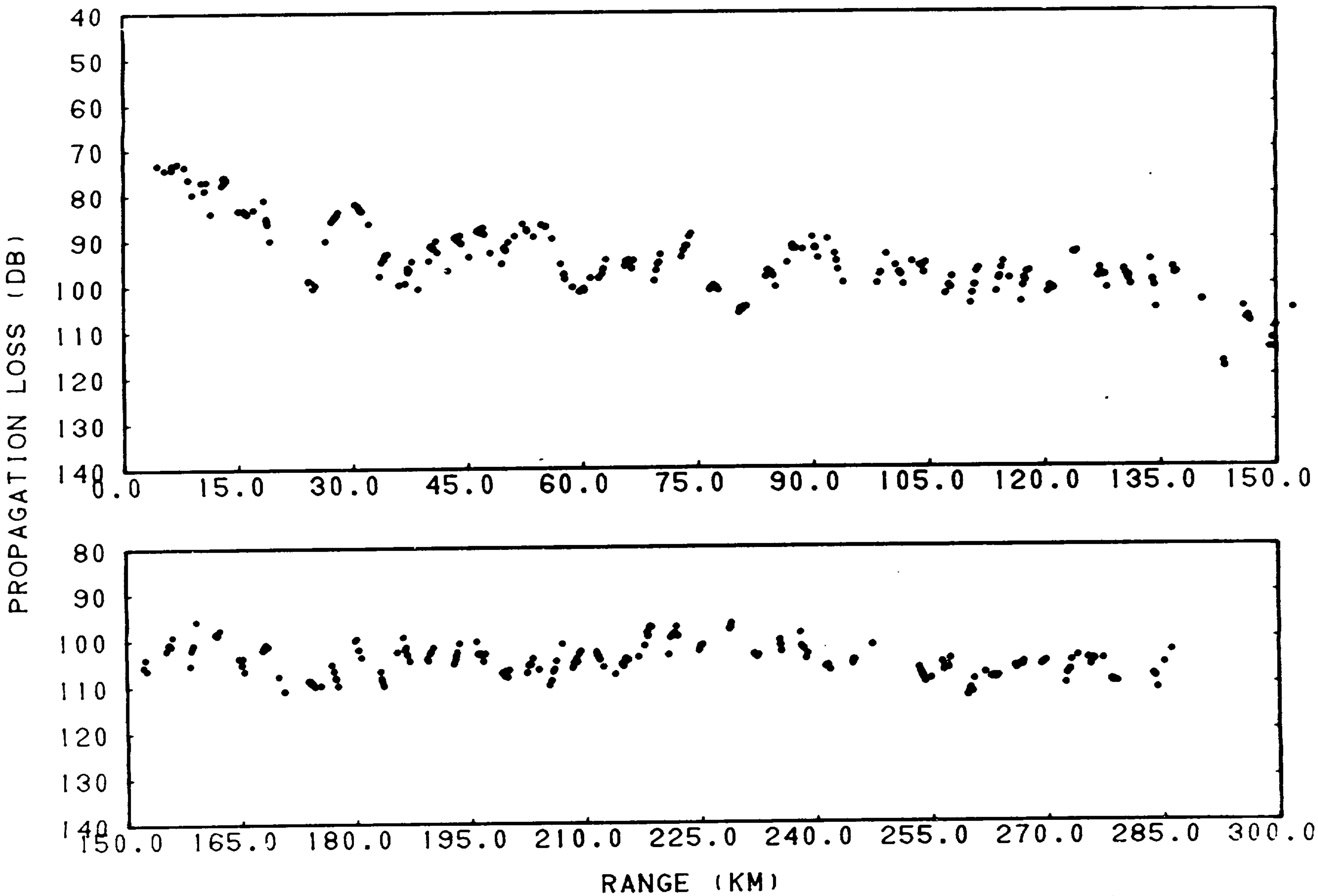
CONFIDENTIAL

(C) Figure IIID-25. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 290 Hertz



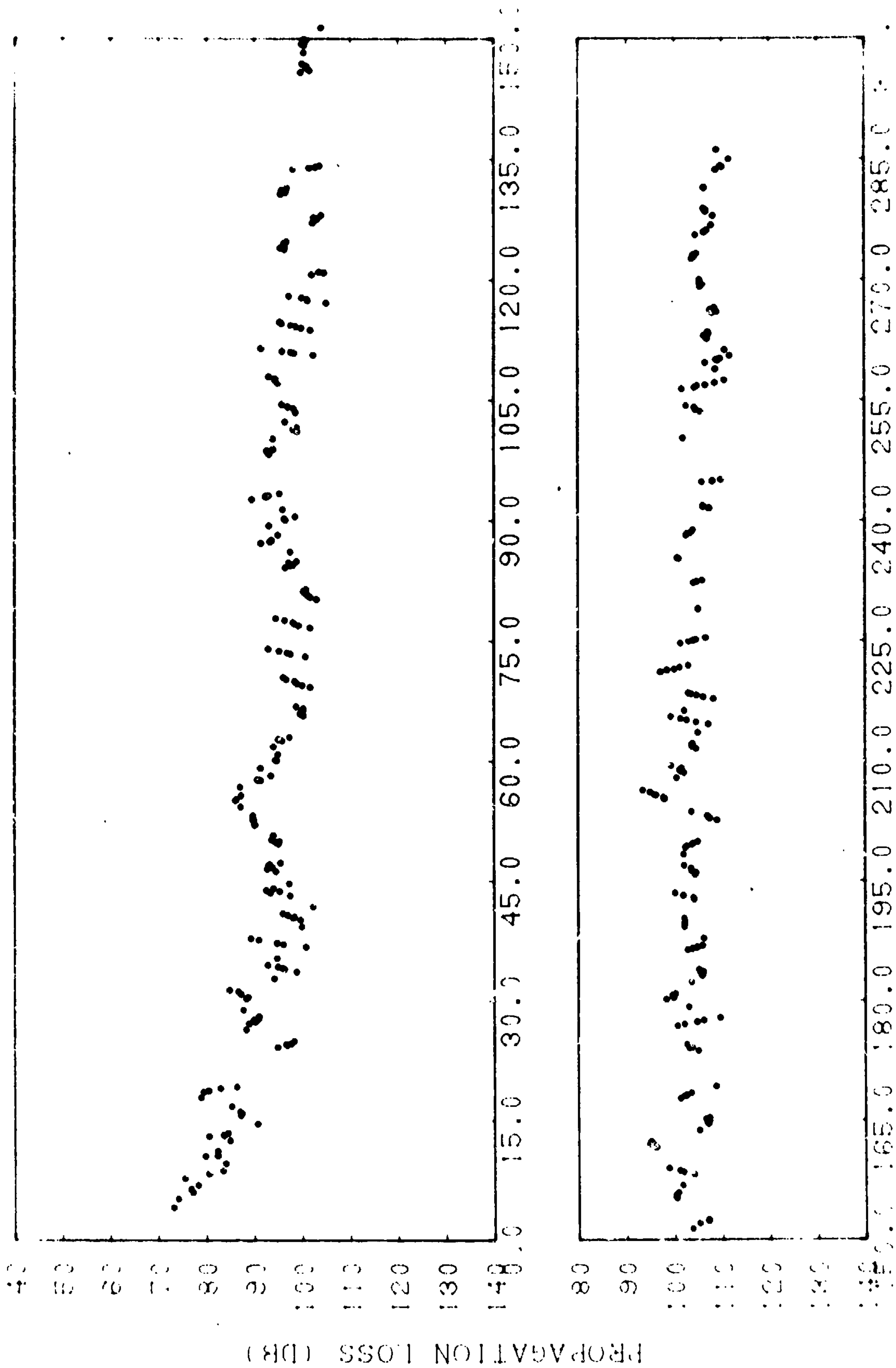
CONFIDENTIAL

(C) Figure IIID-26. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 290 Hertz



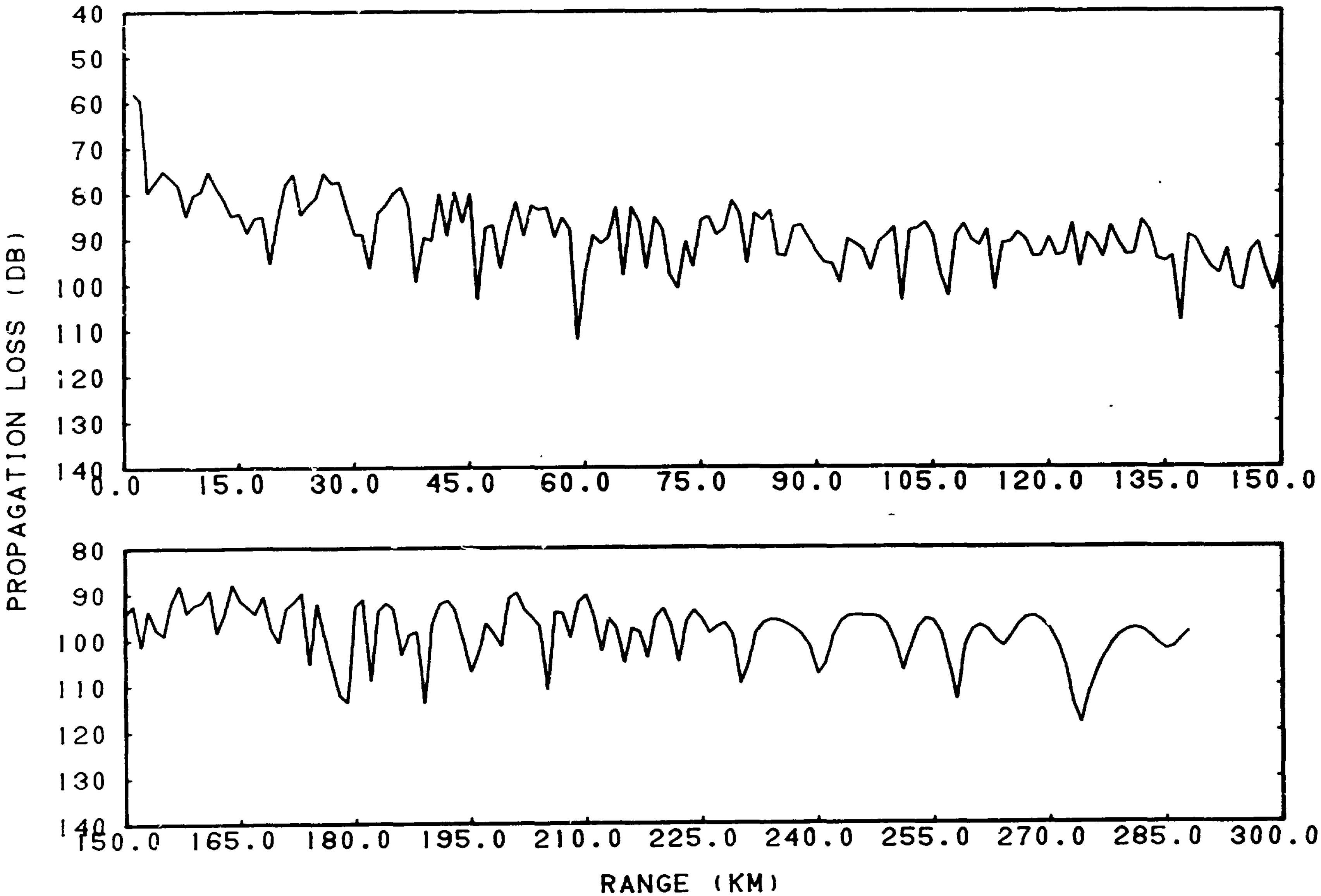
CONFIDENTIAL

(C) Figure IIID-27. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 290 Hertz



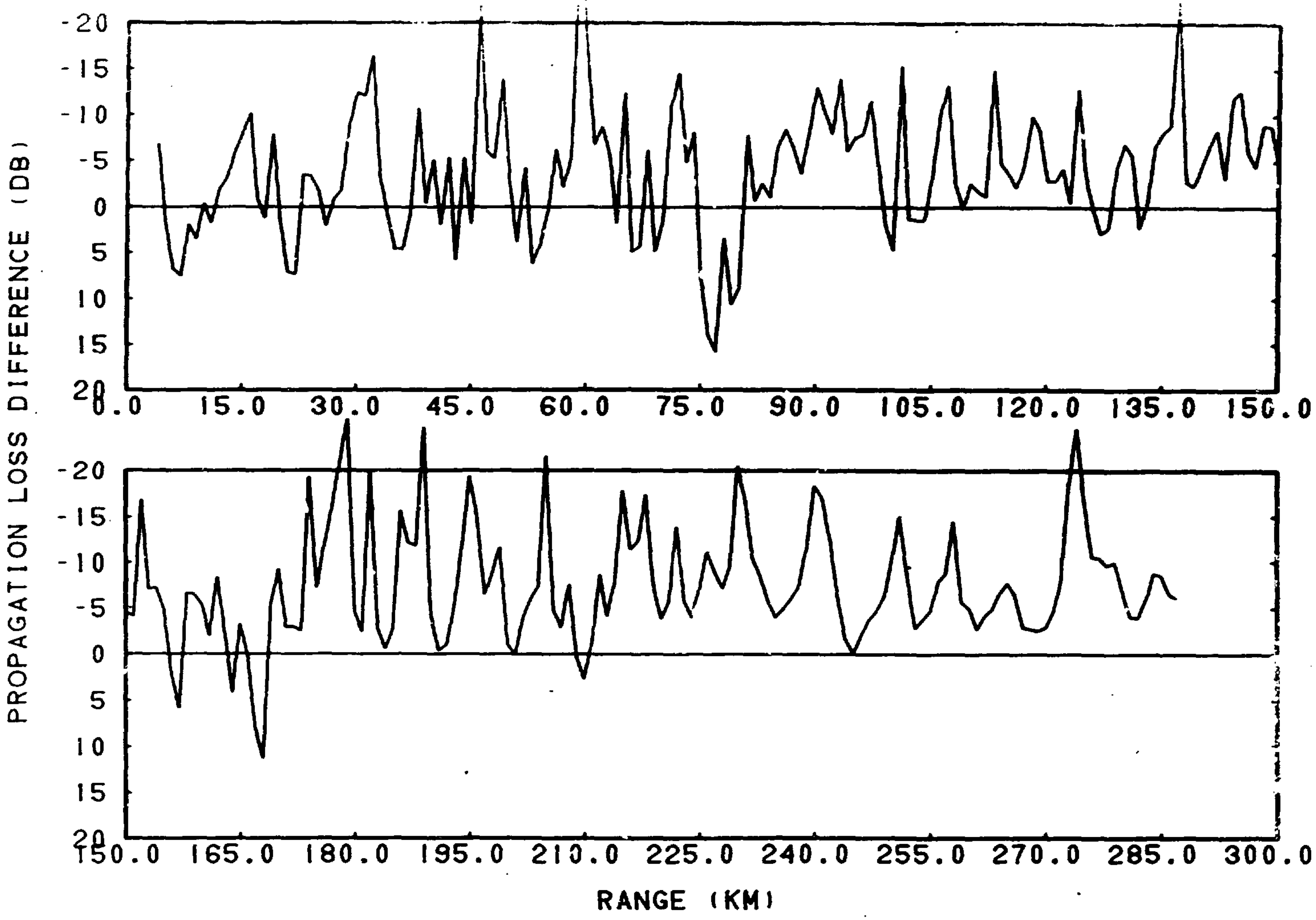
CONFIDENTIAL

(C) Figure IIID-28. Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 290 Hertz



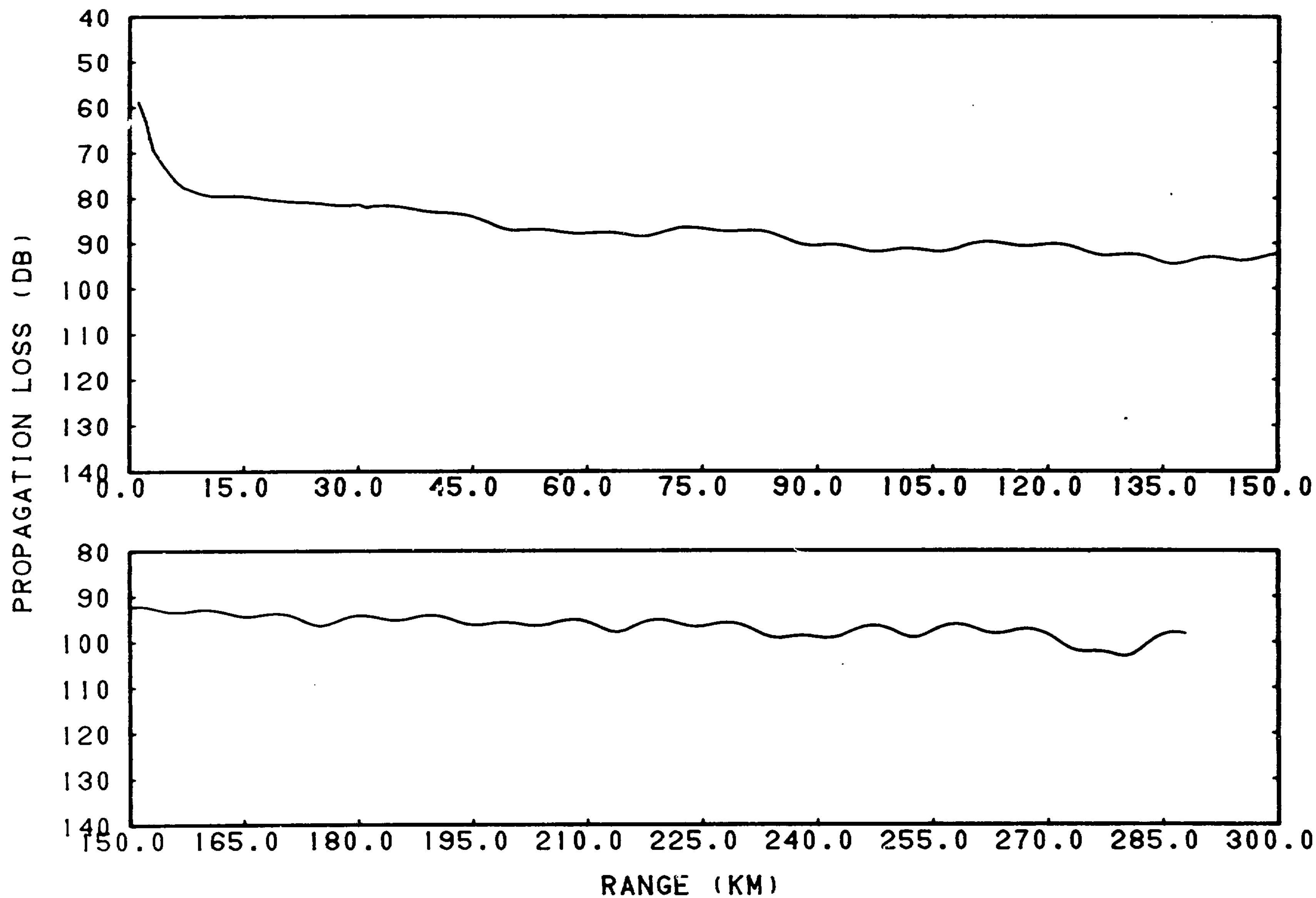
CONFIDENTIAL

(C) Figure IIID-29. RAYMODE Coherent, Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 496 Meters, Frequency = 25 Hertz



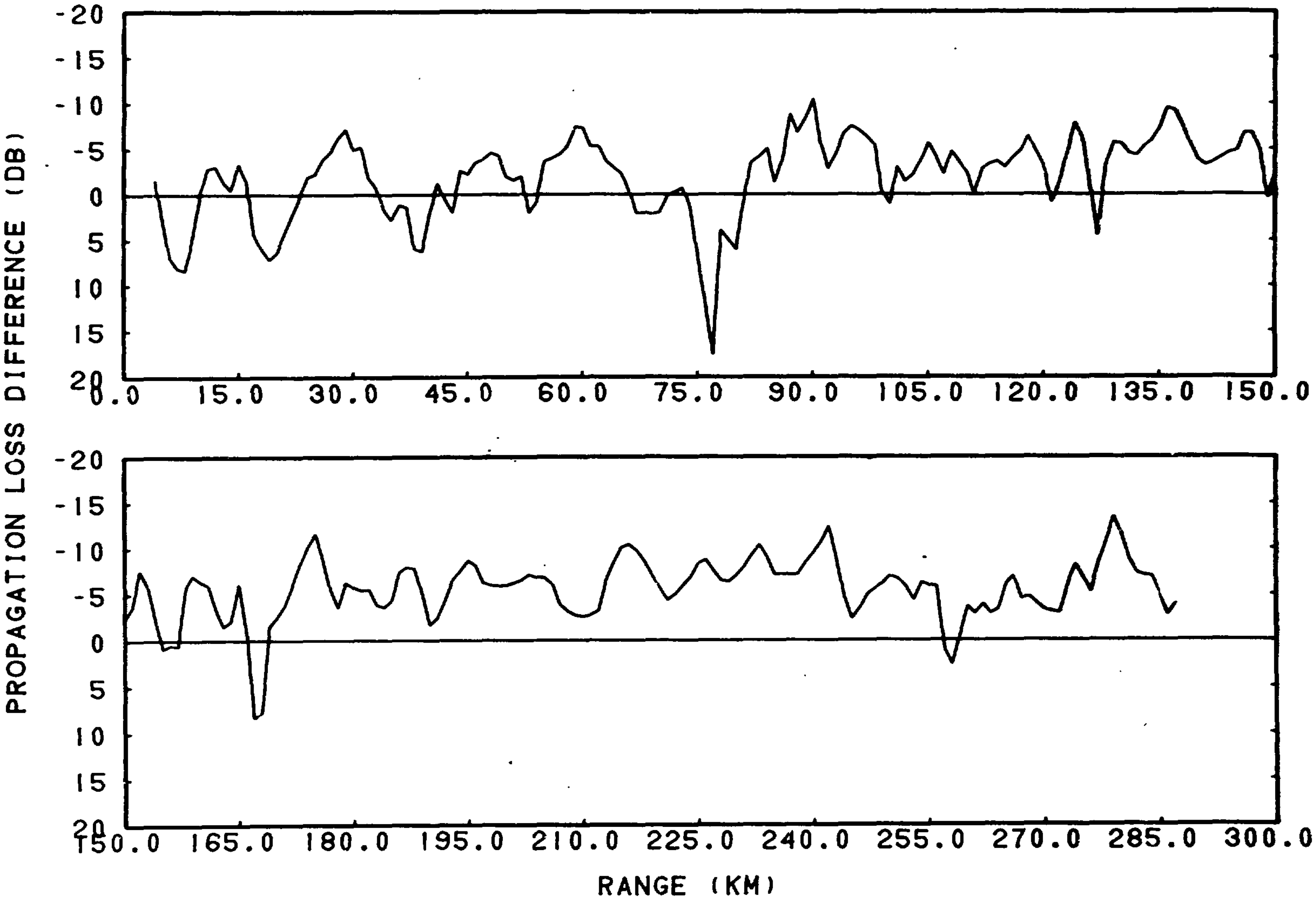
CONFIDENTIAL

(C) Figure IIID-30. RAYMODE Coherent, Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 496 Meters, Frequency = 25 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 496 Meters, Frequency = 25 Hertz



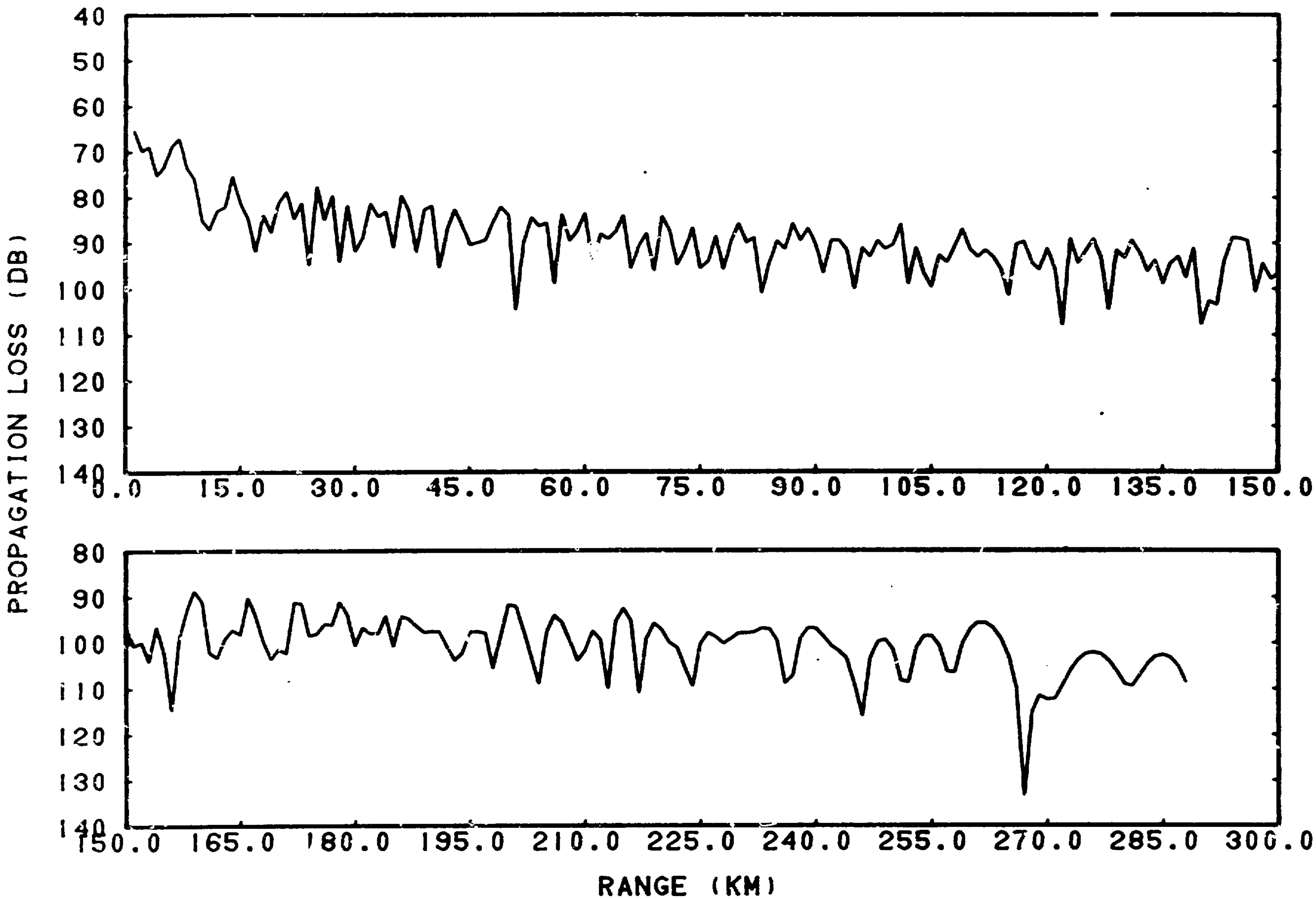
CONFIDENTIAL

(C) Figure IIID-31. RAYMODE Incoherent Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 496 Meters, Frequency = 25 Hertz



CONFIDENTIAL

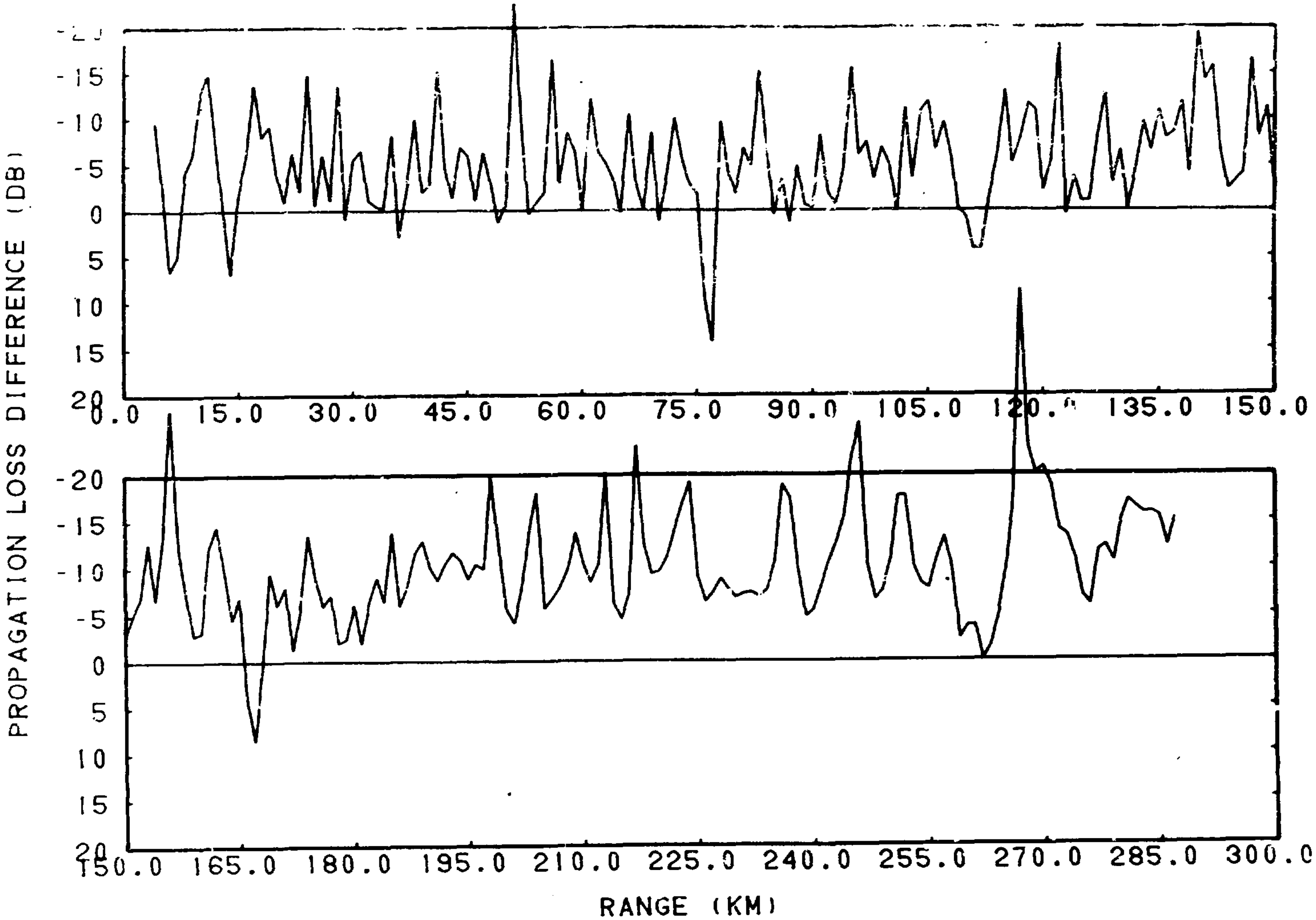
(C) Figure IIID-32. RAYMODE Incoherent Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 496 Meters, Frequency = 25 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 496 Meters, Frequency = 25 Hertz



CONFIDENTIAL

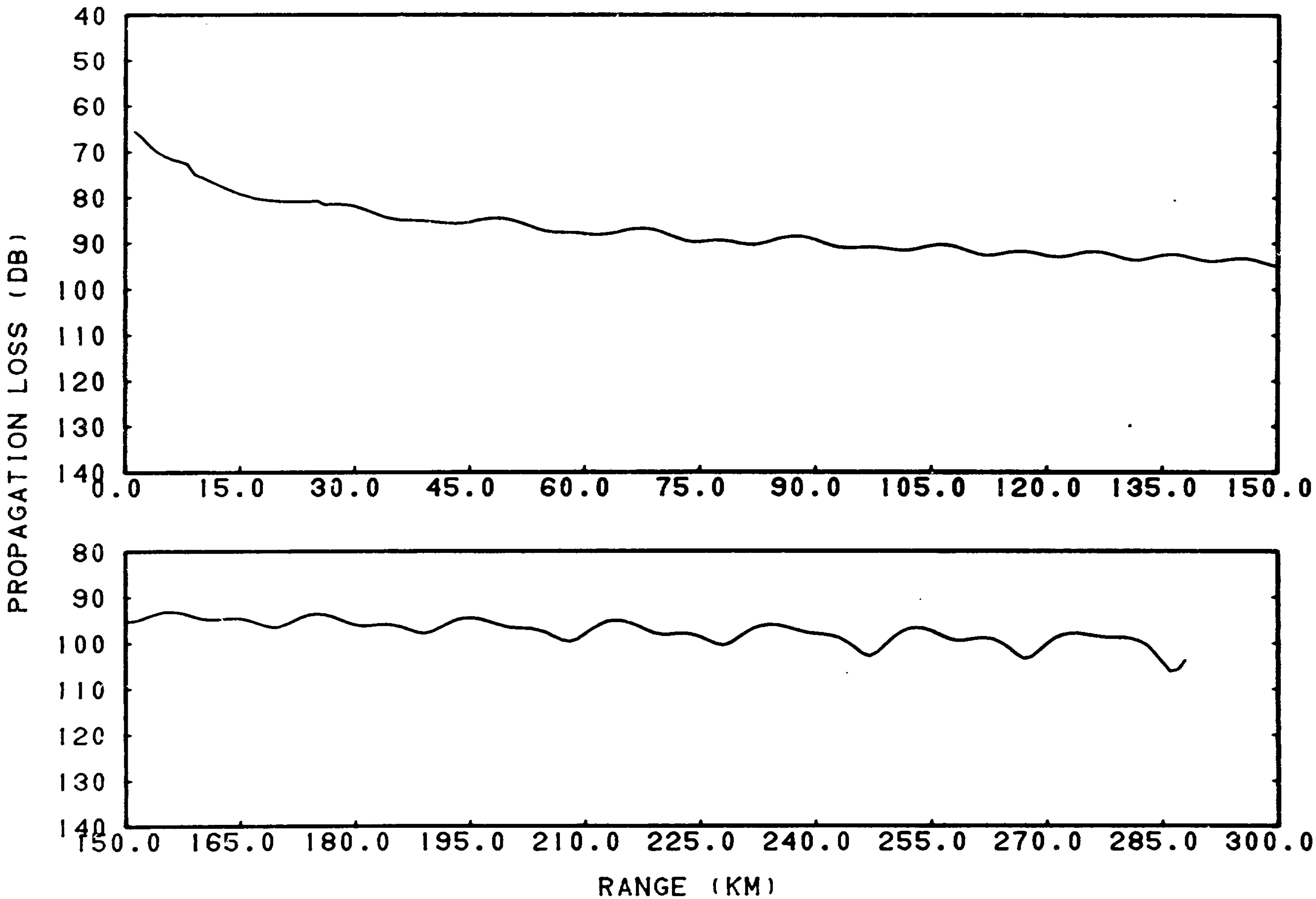
(C) Figure IIID-33. RAYMODE Coherent Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 1685 Meters, Frequency = 25 Hertz

CONFIDENTIAL



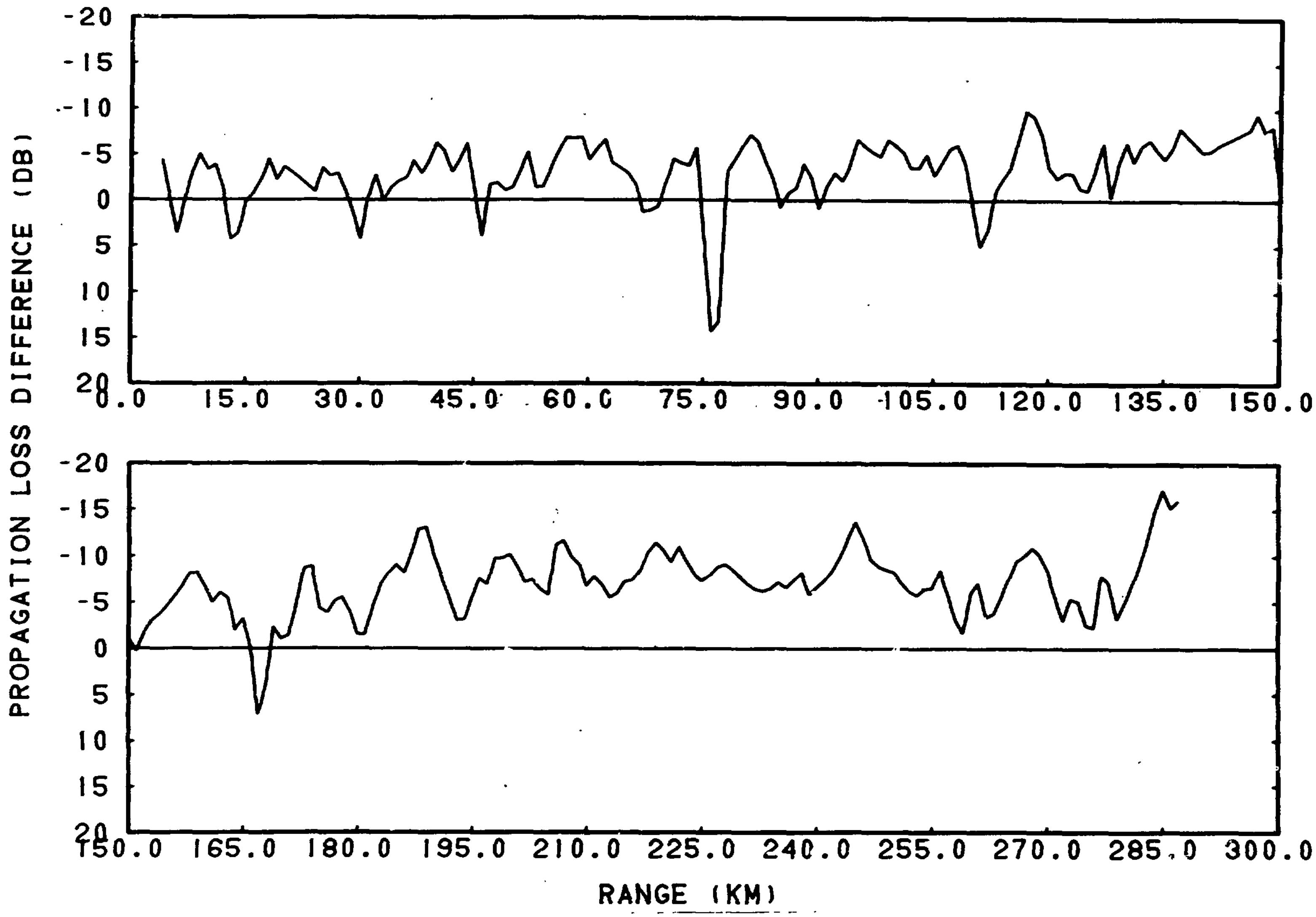
CONFIDENTIAL

(C) Figure IIID-34. RAYMODE Coherent Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 1685 Meters, Frequency = 25 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 1685 Meters, Frequency = 25 Hertz



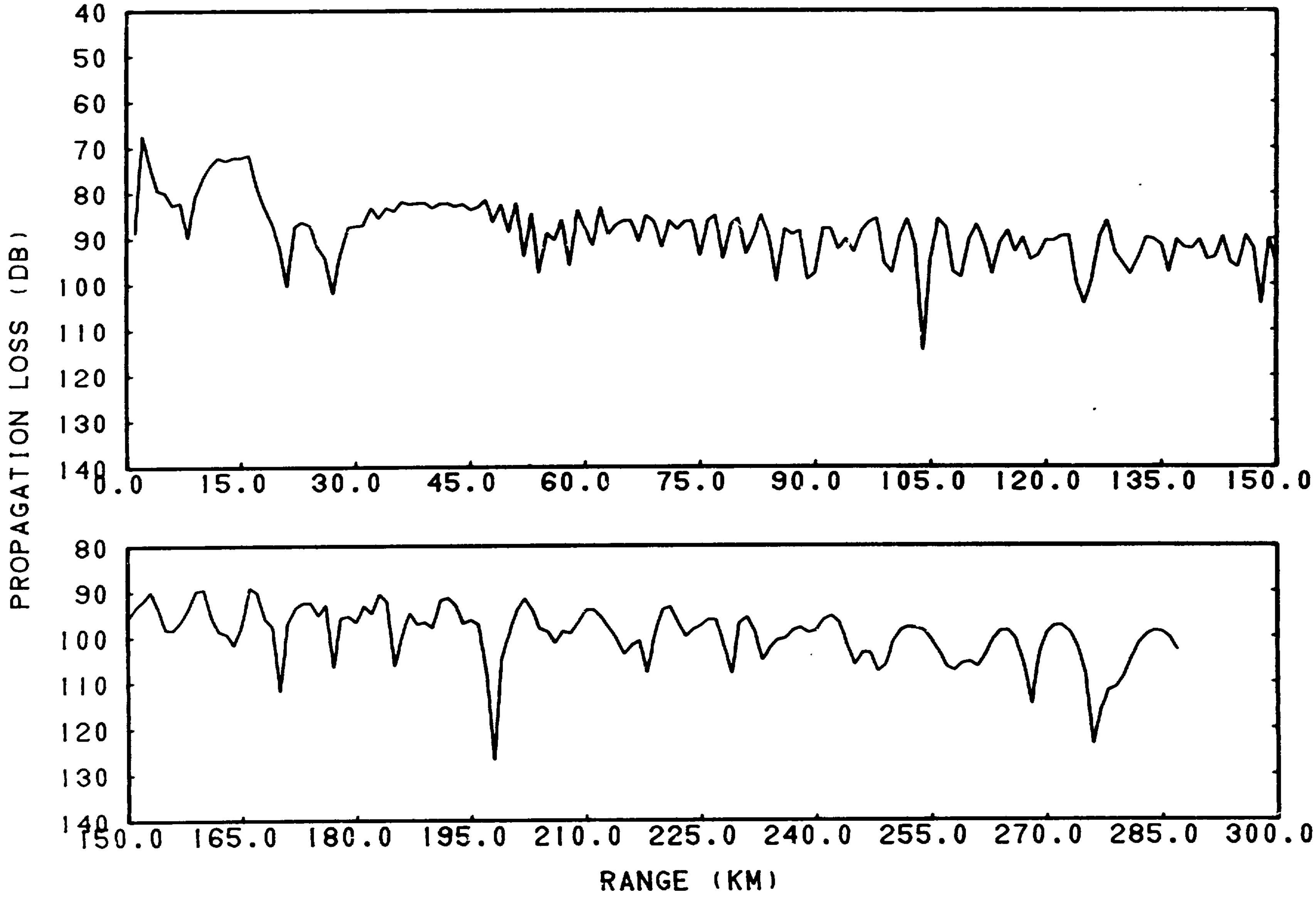
CONFIDENTIAL

(C) Figure IIID-35. RAYMODE Incoherent Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 1685 Meters, Frequency = 25 Hertz



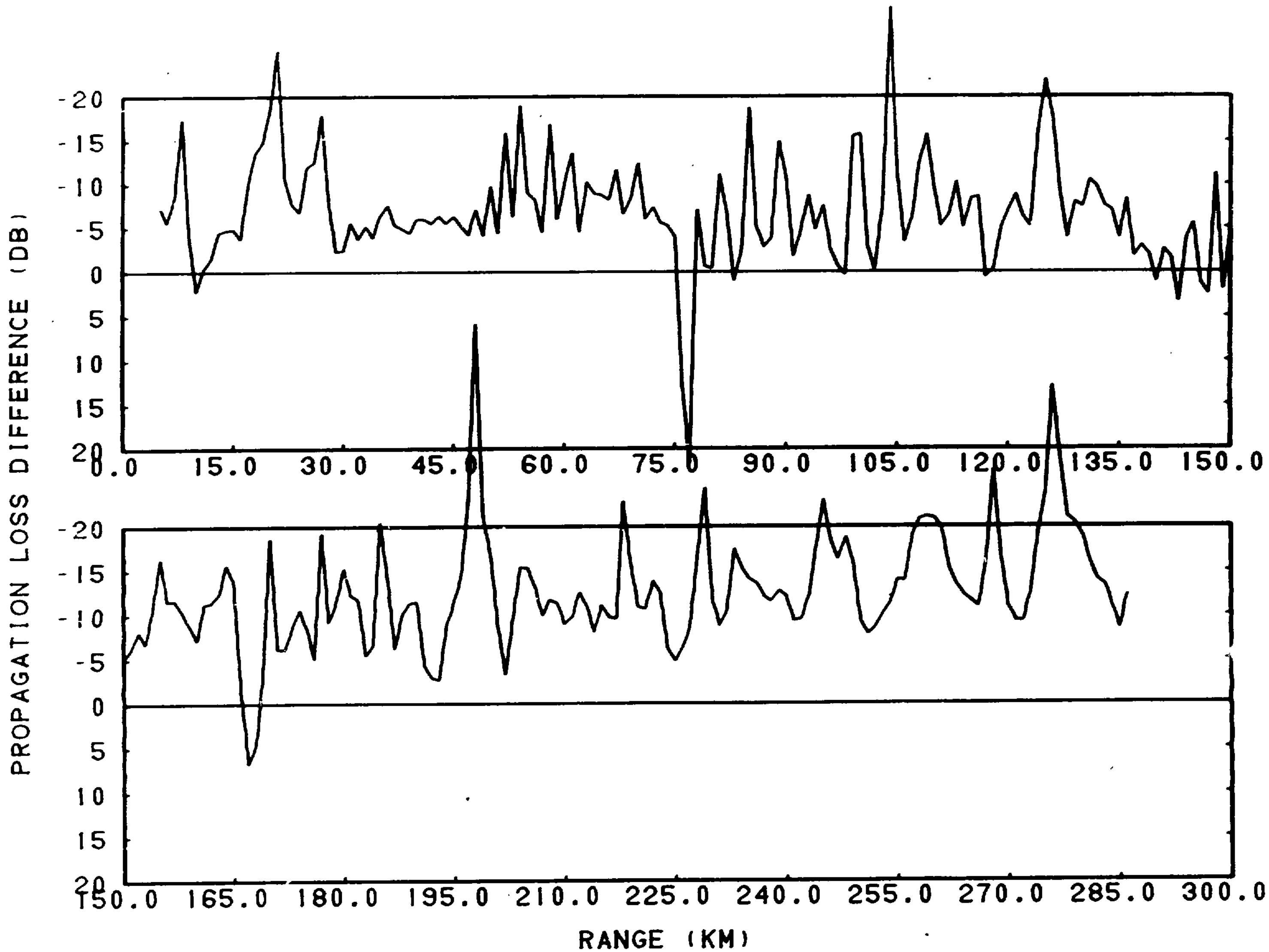
CONFIDENTIAL

(C) Figure IIID-36. RAYMODE Incoherent Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 1685 Meters, Frequency = 25 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 1685 Meters, Frequency = 25 Hertz



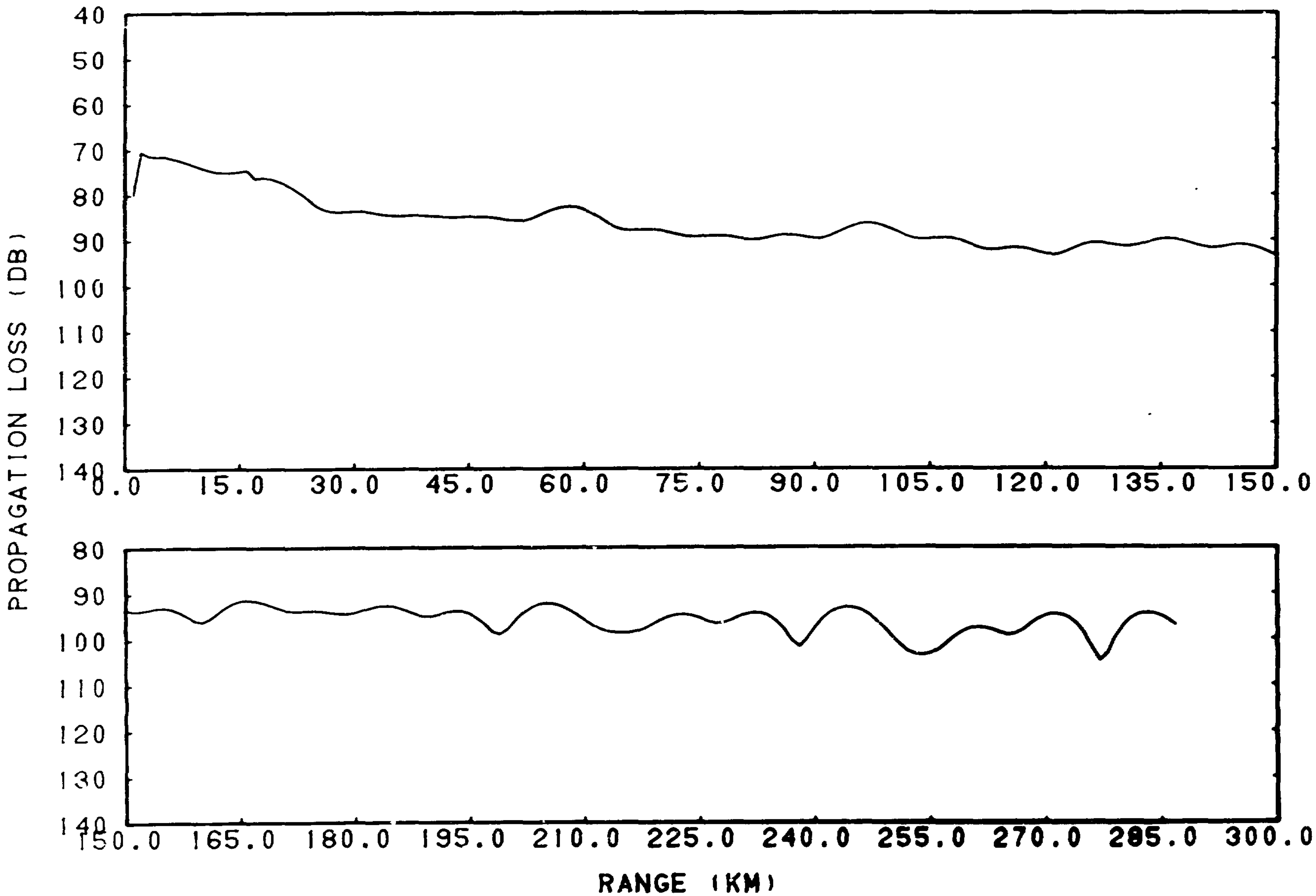
CONFIDENTIAL

(C) Figure IIID-37. RAYMODE Coherent Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3320 Meters, Frequency = 25 Hertz



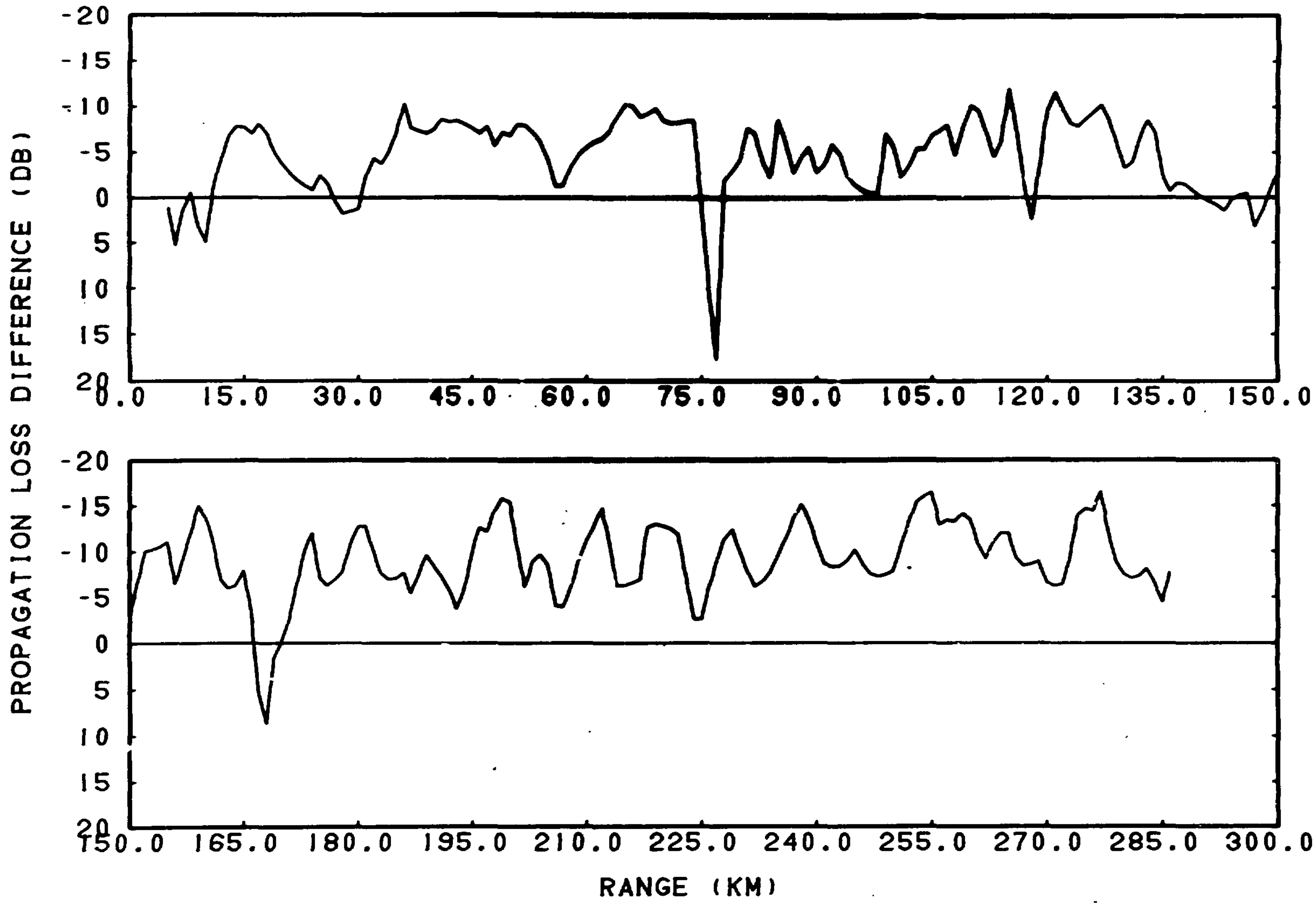
CONFIDENTIAL

(C) Figure IIID-38. RAYMODE Coherent Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3320 Meters, Frequency = 25 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3320 Meters, Frequency = 25 Hertz



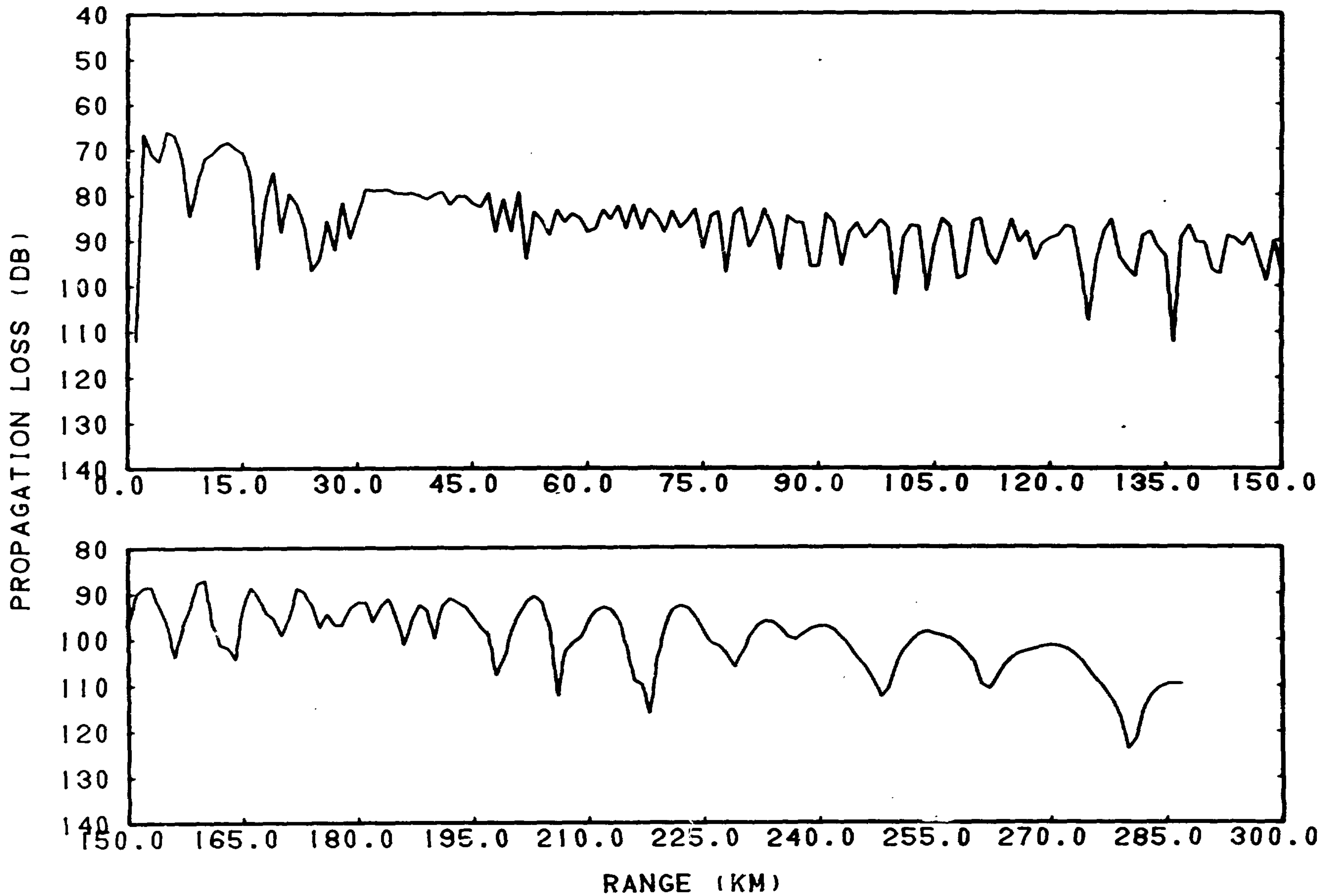
CONFIDENTIAL

(C) Figure IIID-39. **RAYMODE Incoherent Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth - 3320 Meters, Frequency = 25 Hertz**



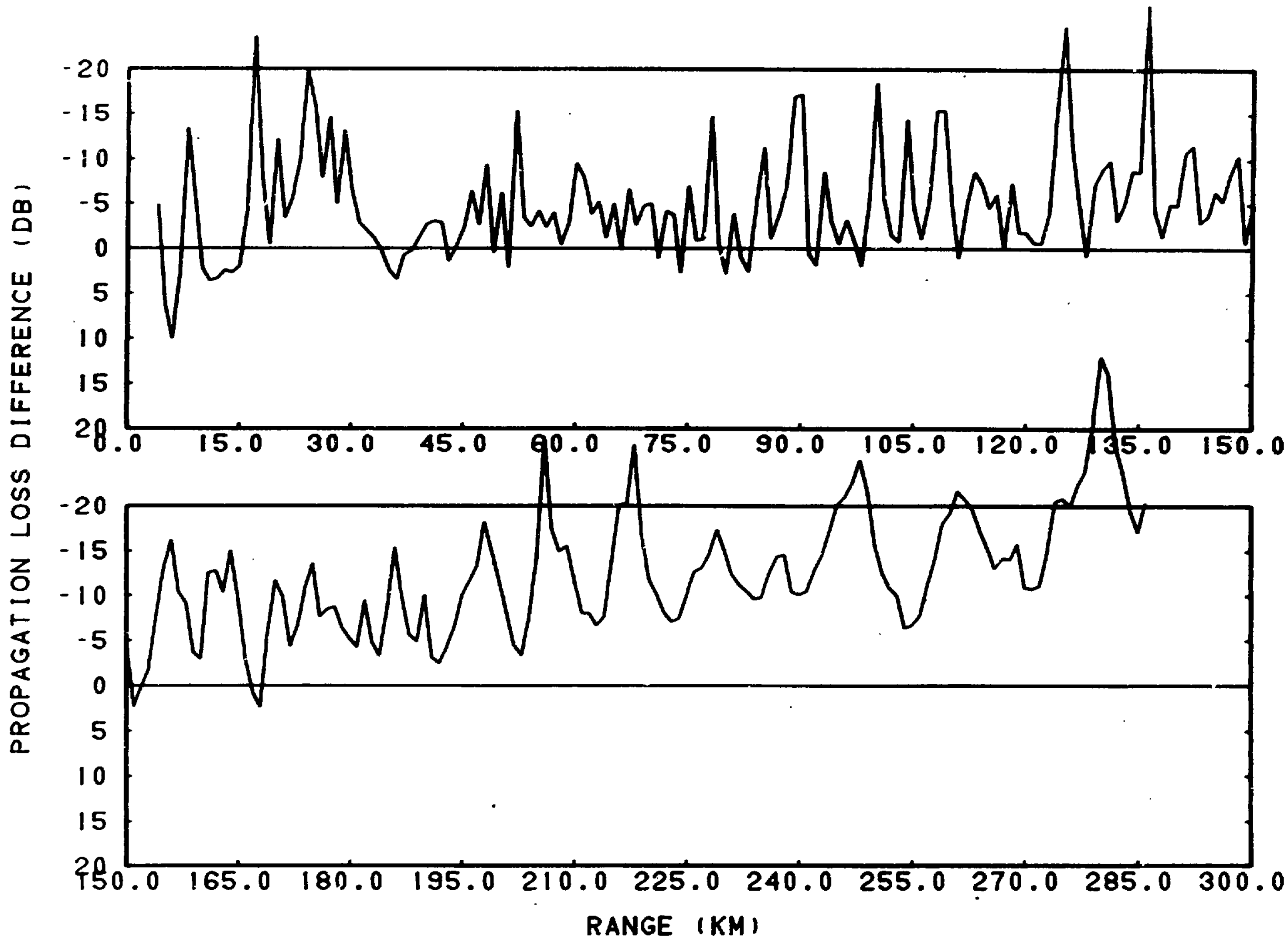
CONFIDENTIAL

(C) Figure IIID-40. RAYMODE Incoherent Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3320 Meters, Frequency = 25 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3320 Meters, Frequency = 25 Hertz



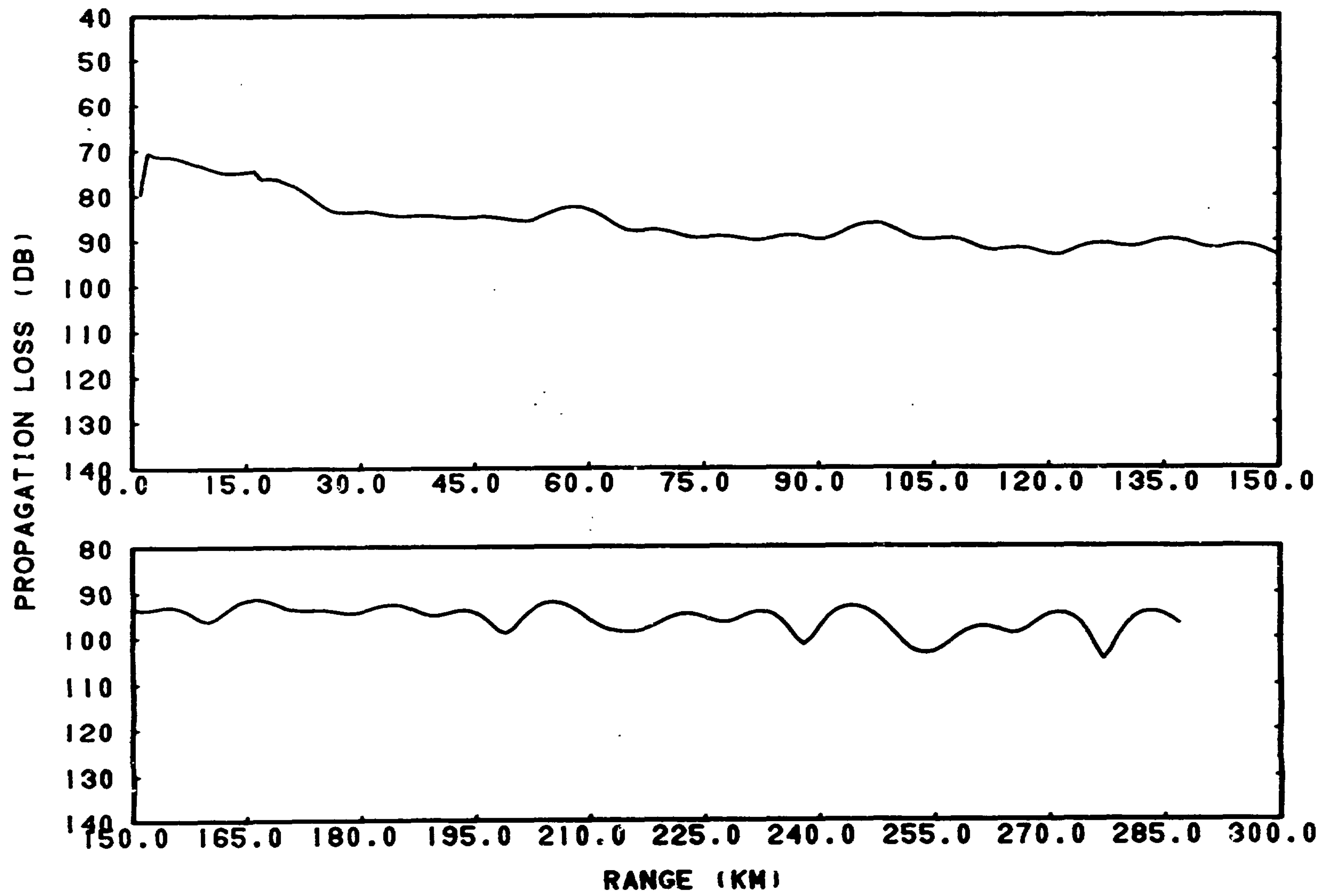
CONFIDENTIAL

(C) Figure IIID-41. RAYMODE Coherent Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3350 Meters, Frequency = 25 Hertz



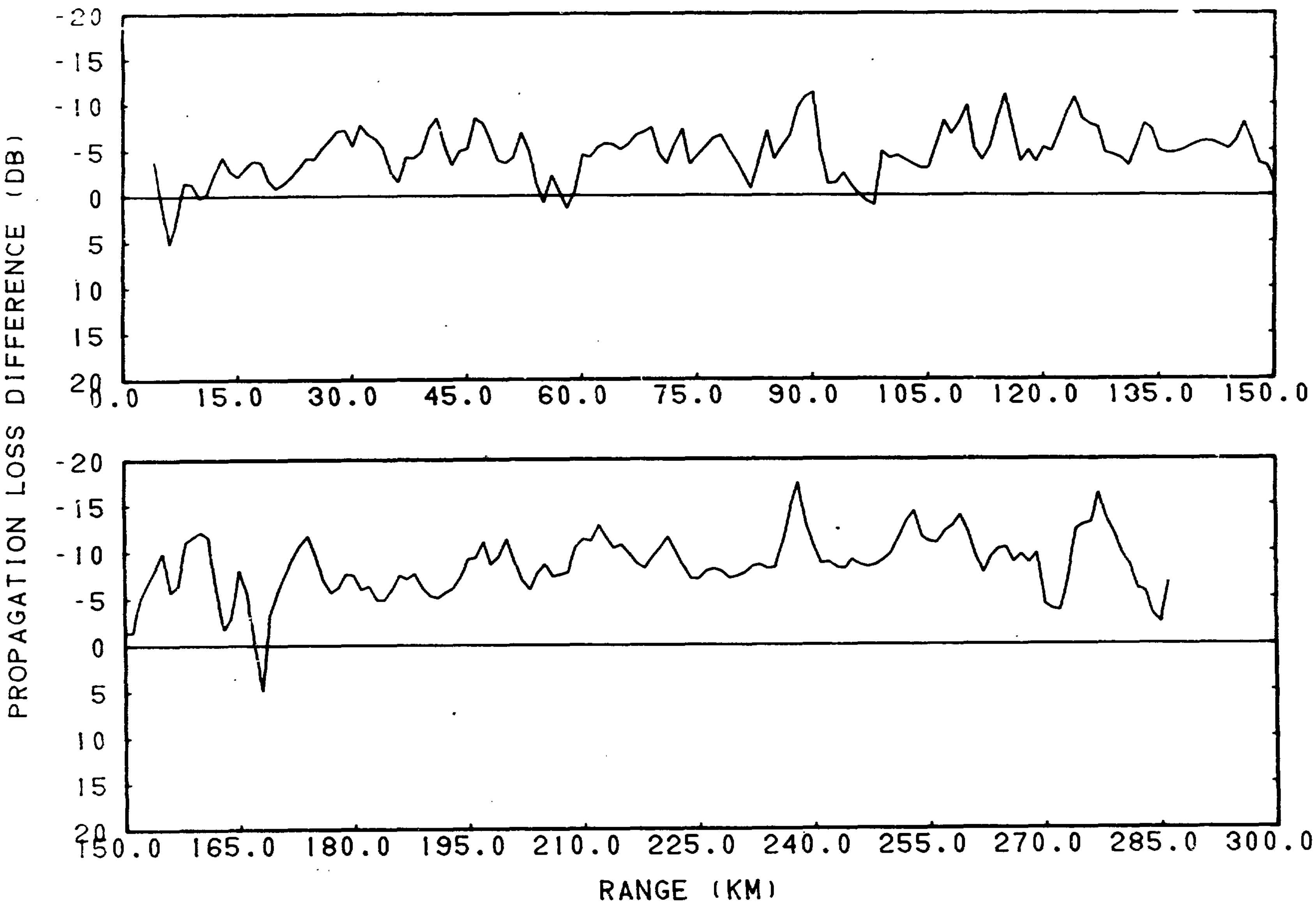
CONFIDENTIAL

(C) Figure IIID-42. RAYMODE Coherent Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3350 Meters, Frequency = 25 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3350 Meters, Frequency = 25 Hertz



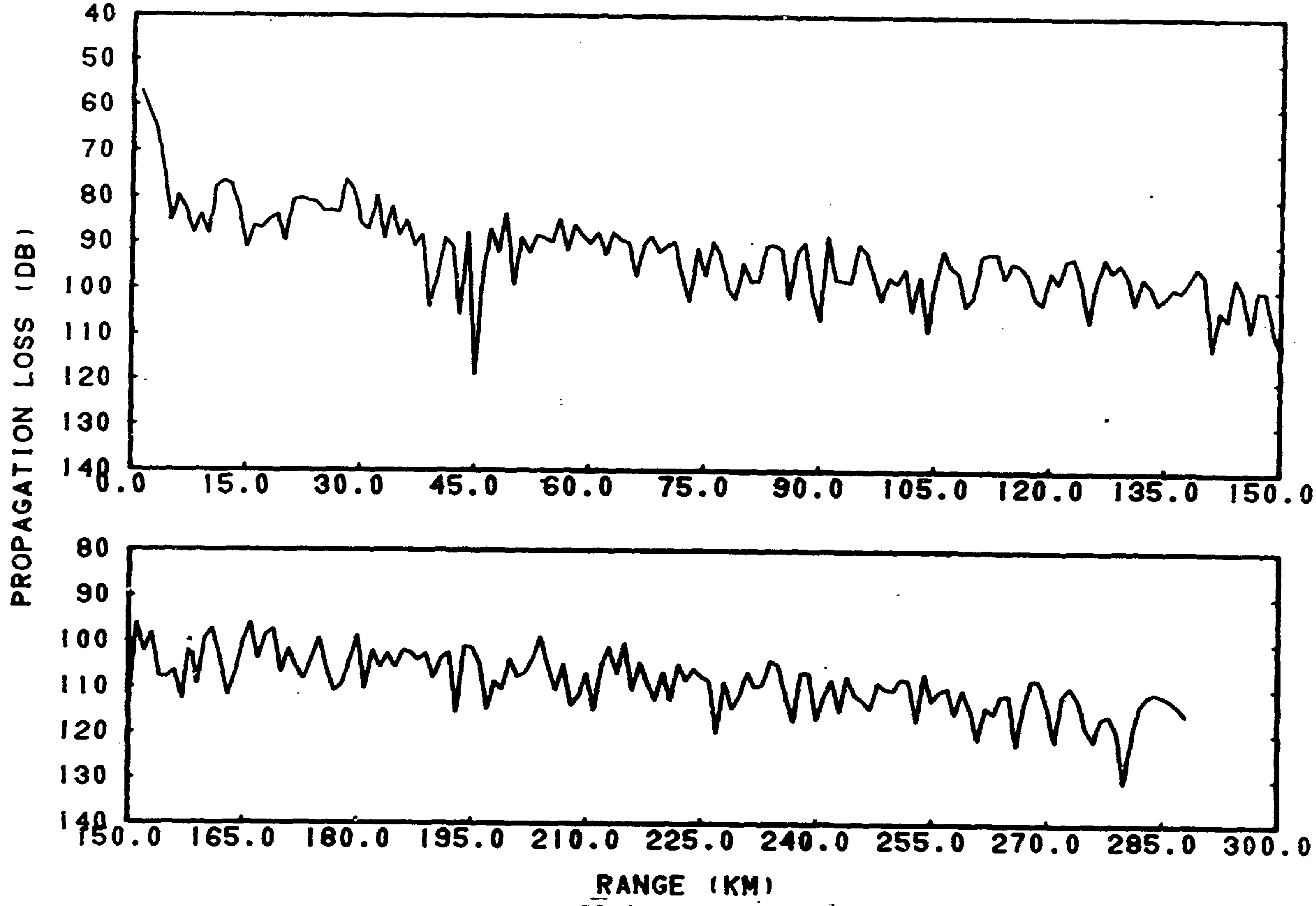
CONFIDENTIAL

(C) Figure IIID-43. RAYMODE Incoherent Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3350 Meters, Frequency = 25 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 91 Meters, Receiver Depth = 3350 Meters, Frequency = 25 Hertz



CONFIDENTIAL

(C) Figure IIID-44. RAYMODE Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 140 Hertz



CONFIDENTIAL

(C) Figure IIID-45. RAYMODE Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 140 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 ..eters, Receiver Depth = 496 Meters, Frequency = 140 Hertz

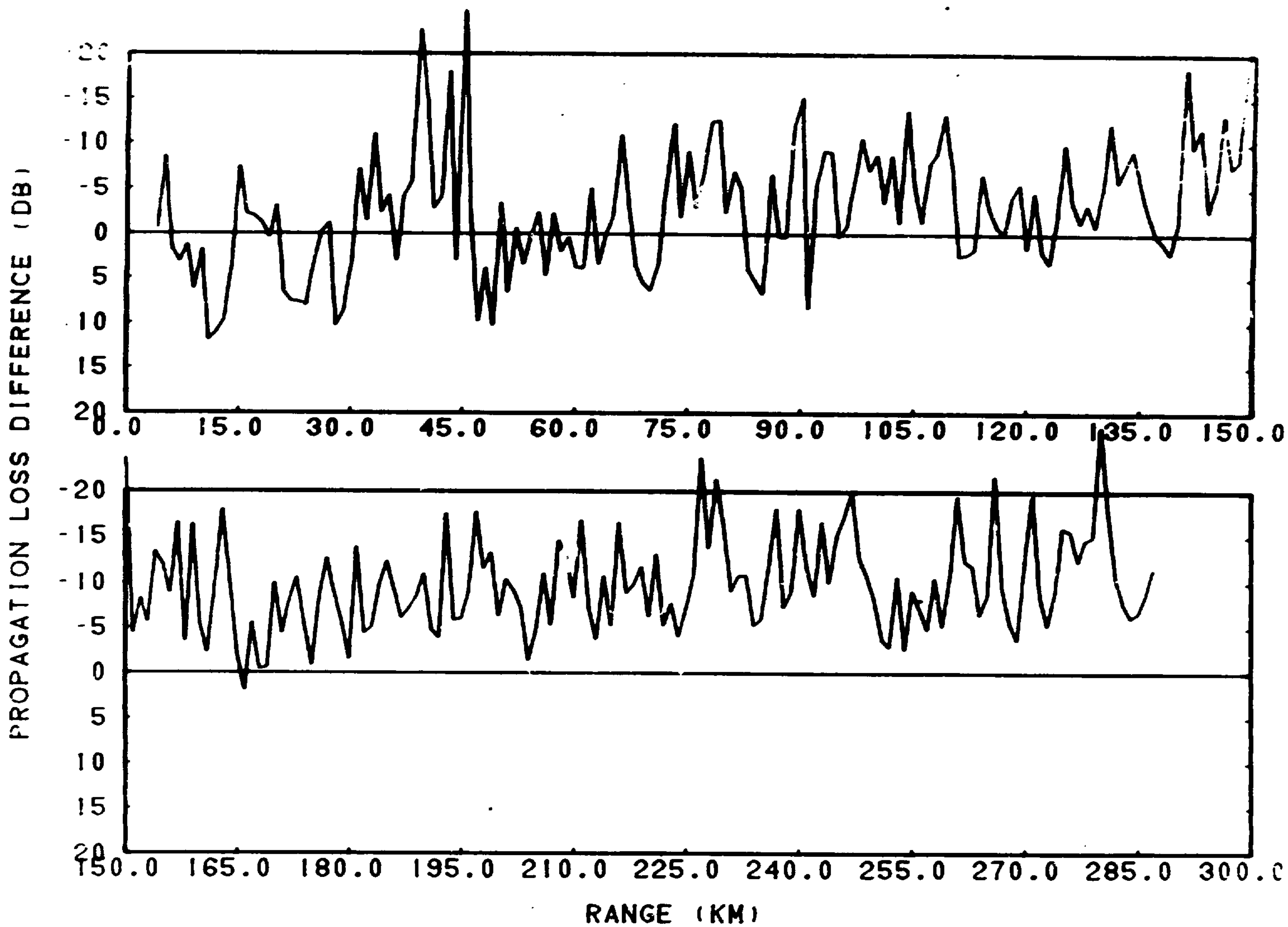
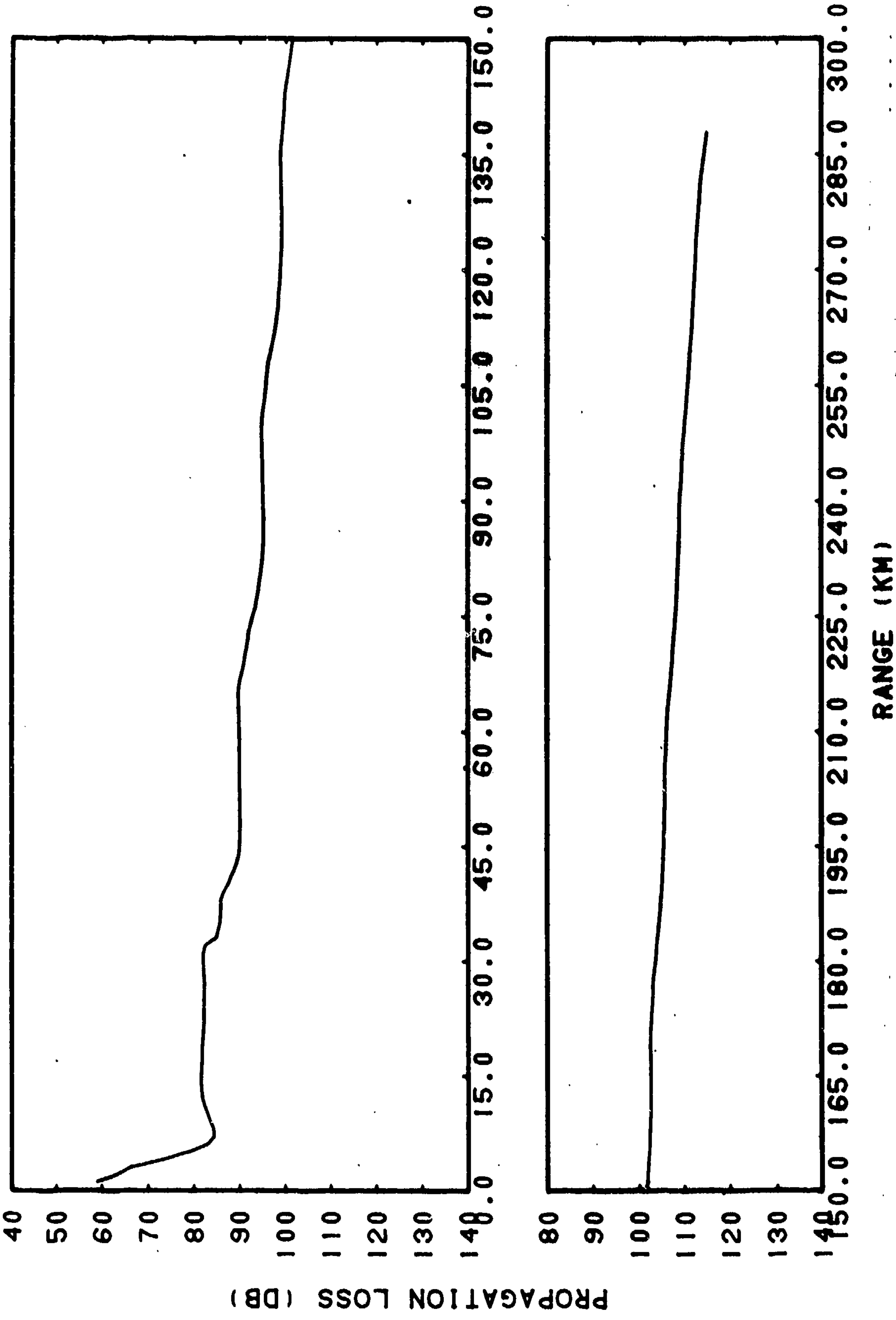
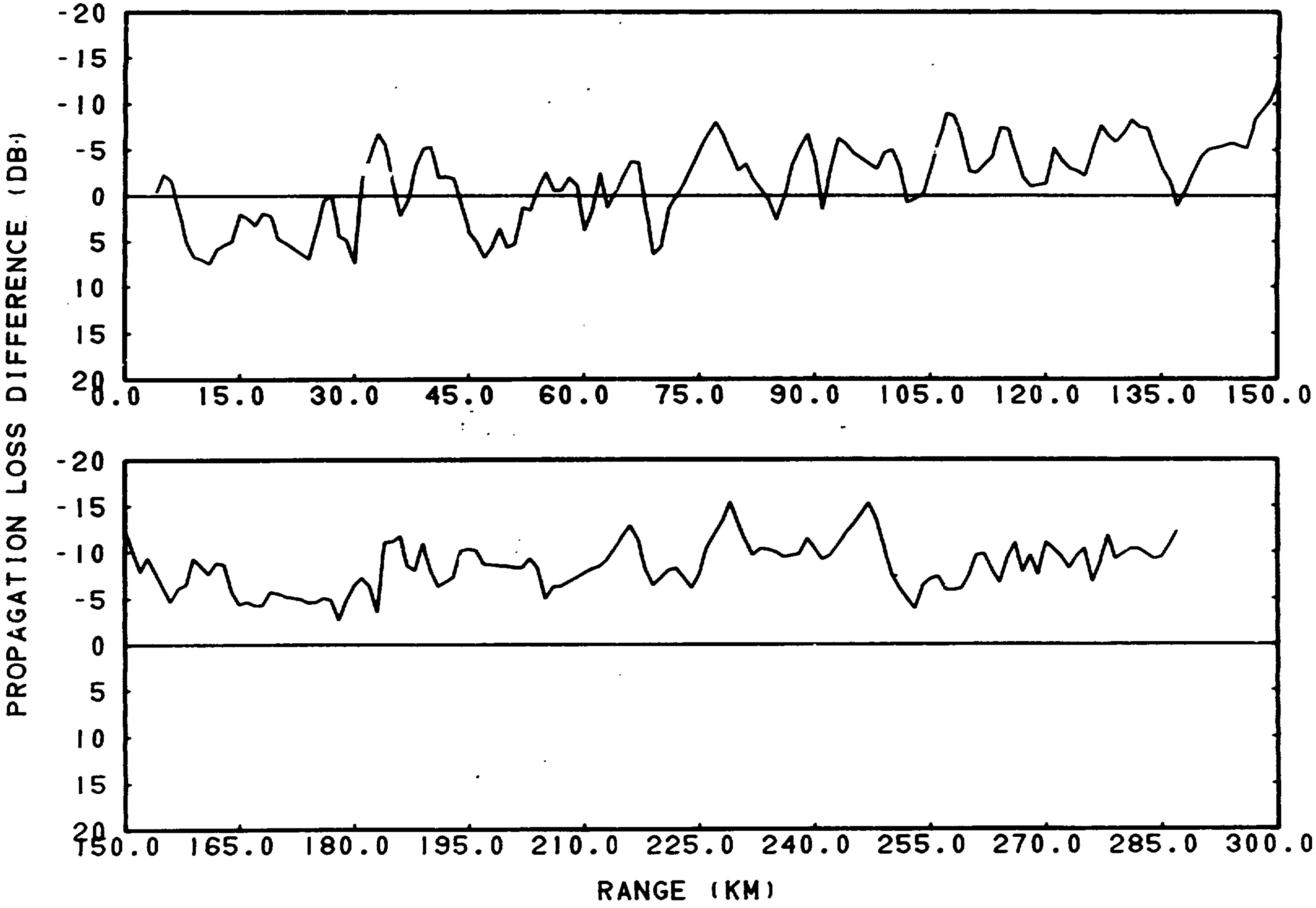


Figure IIID-46. RAYMODE Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 140 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 140 Hertz



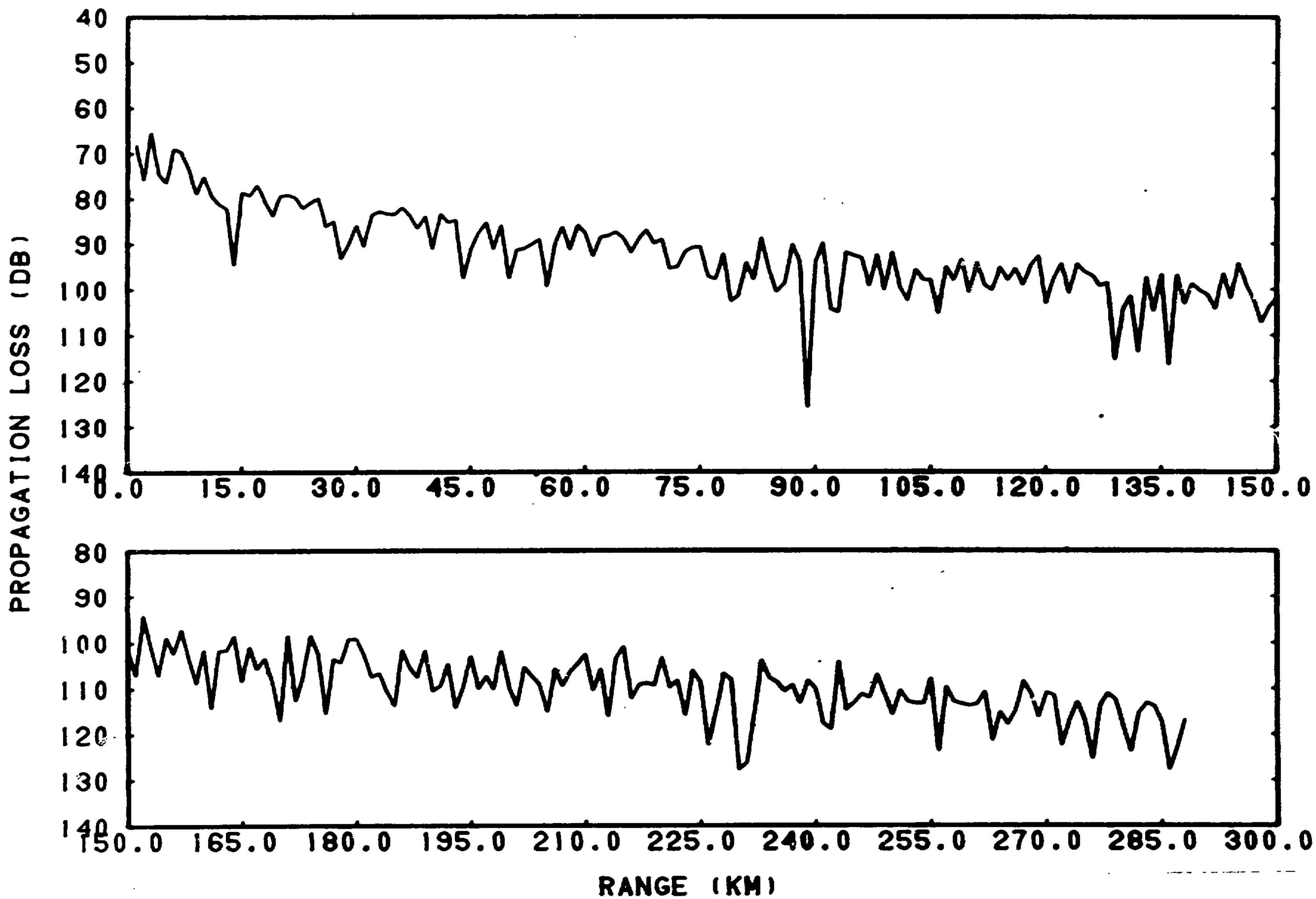
CONFIDENTIAL

(C) Figure IIID-47. RAYMODE Incoherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 140 Hertz



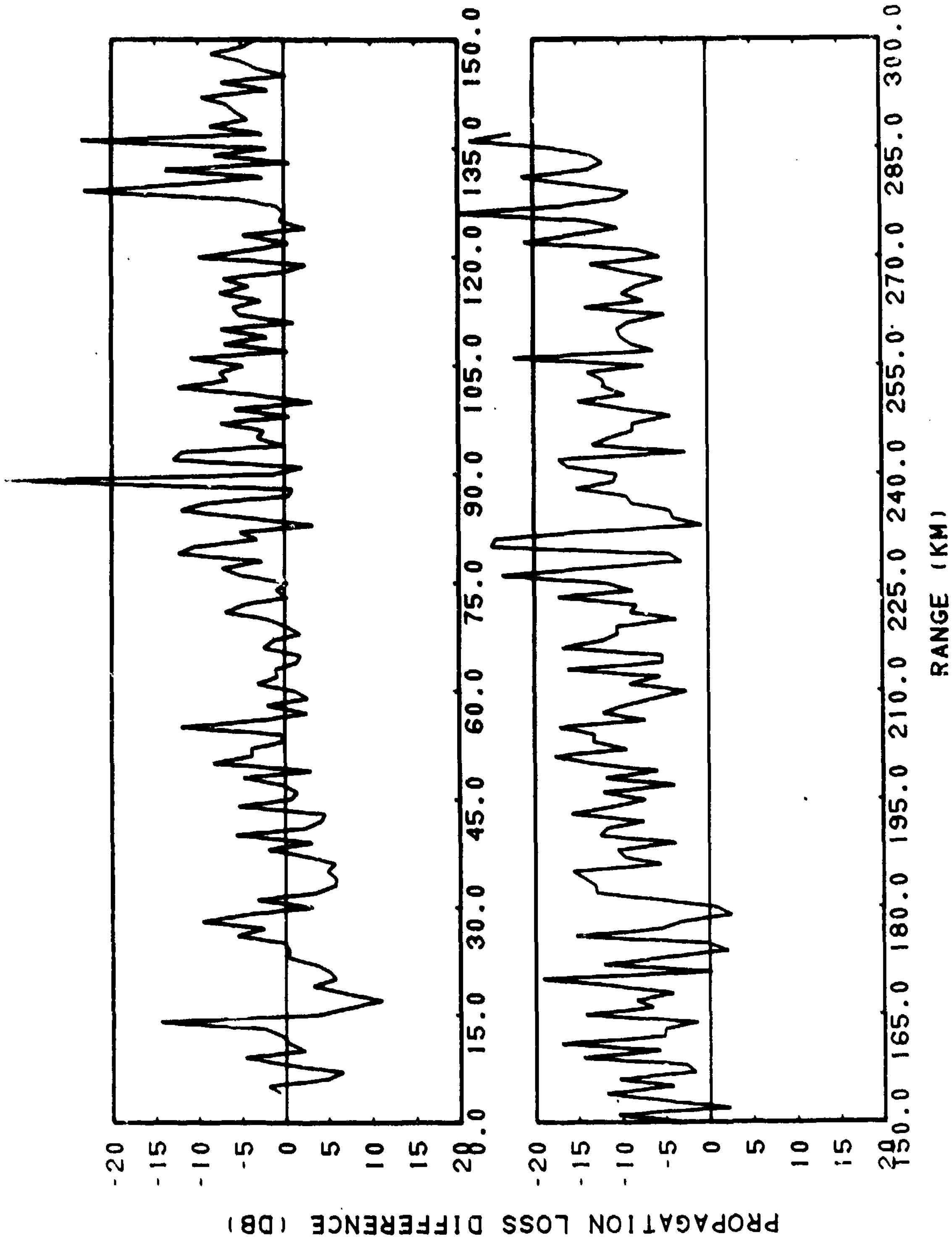
CONFIDENTIAL

(C) Figure IIID-48. RAYMODE Incoherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 140 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 140 Hertz



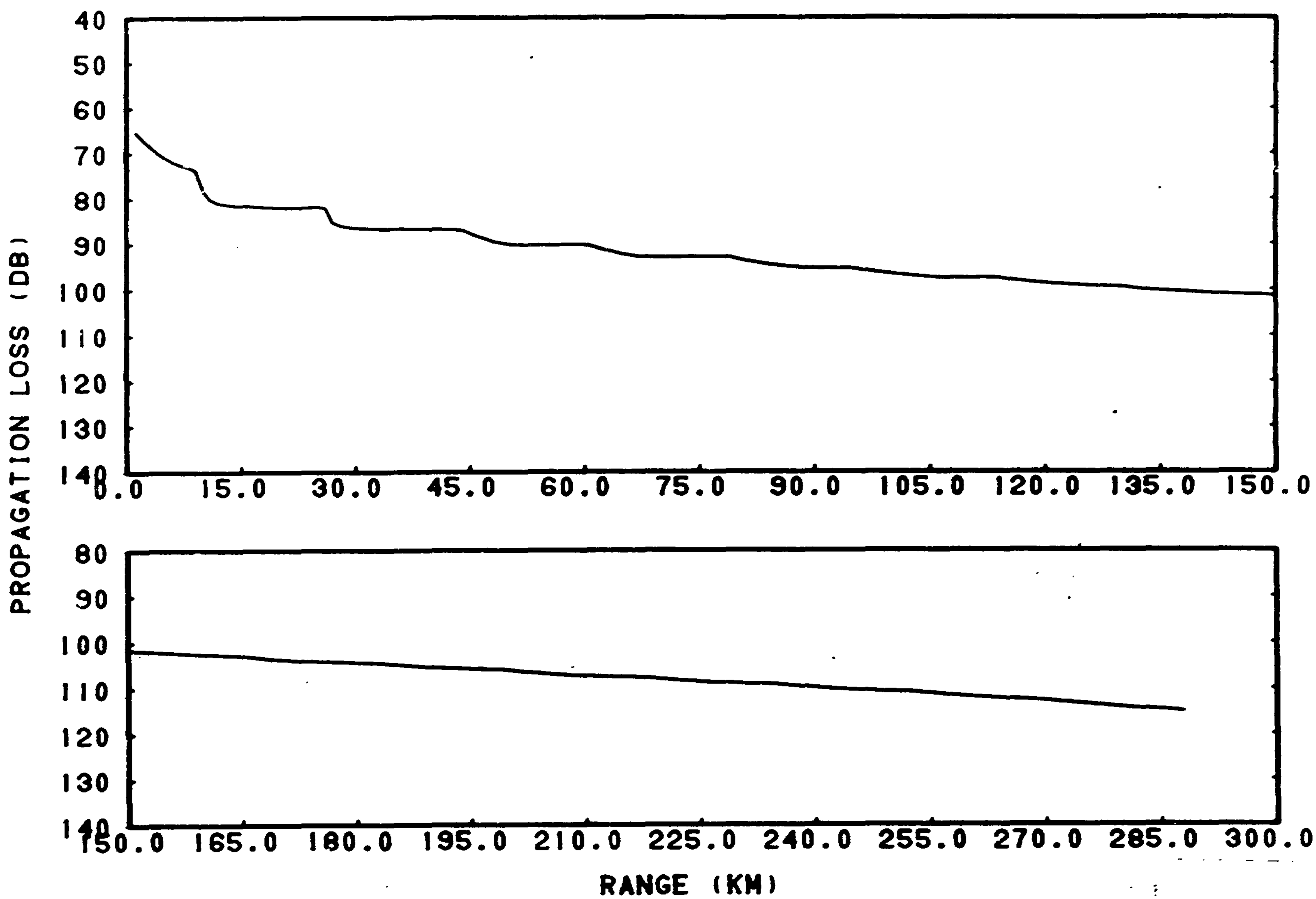
CONFIDENTIAL

(C) Figure IIID-49. RAYMODE Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 140 Hertz



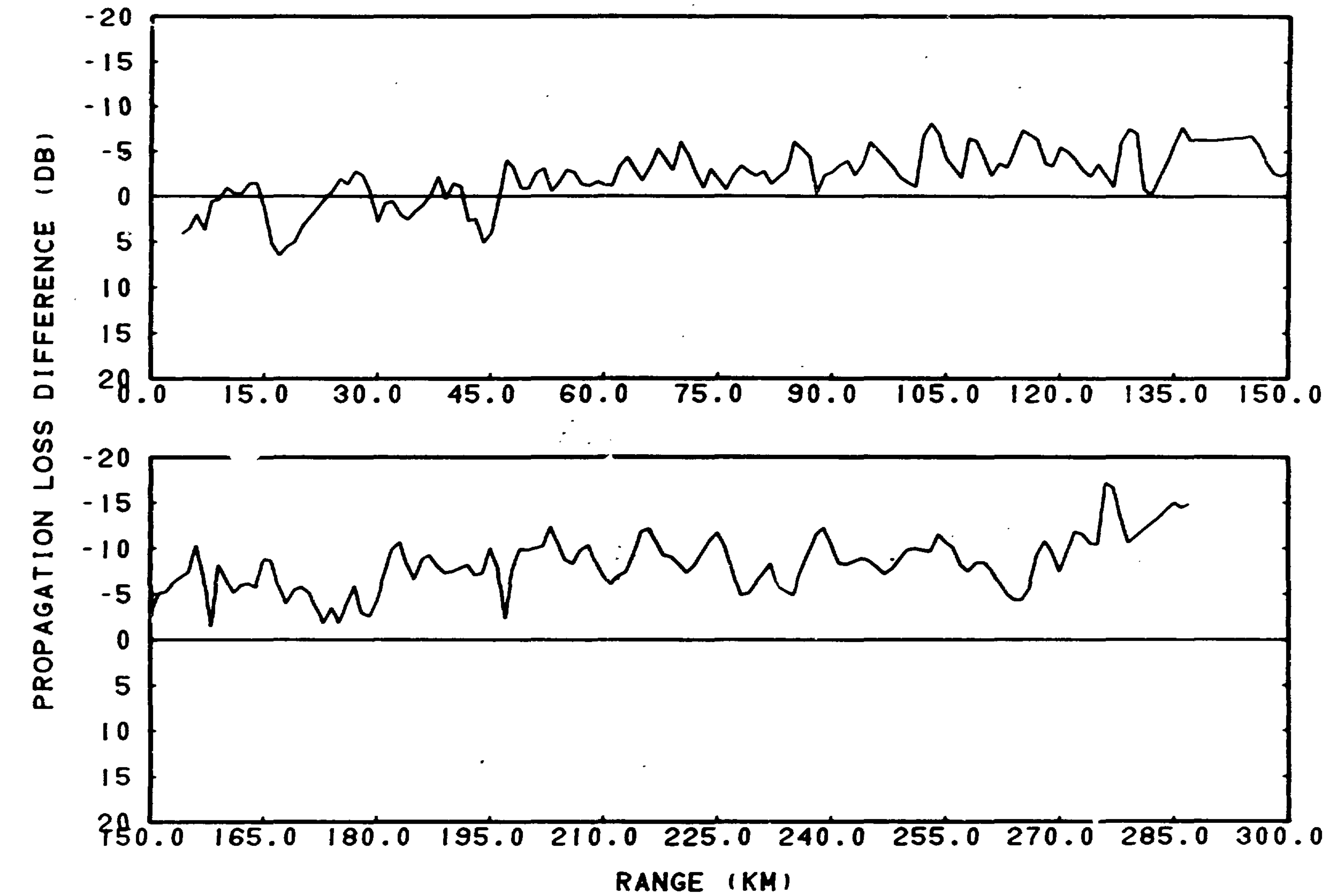
CONFIDENTIAL

(C) Figure IIID-50. RAYMODE Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 140 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 140 Hertz



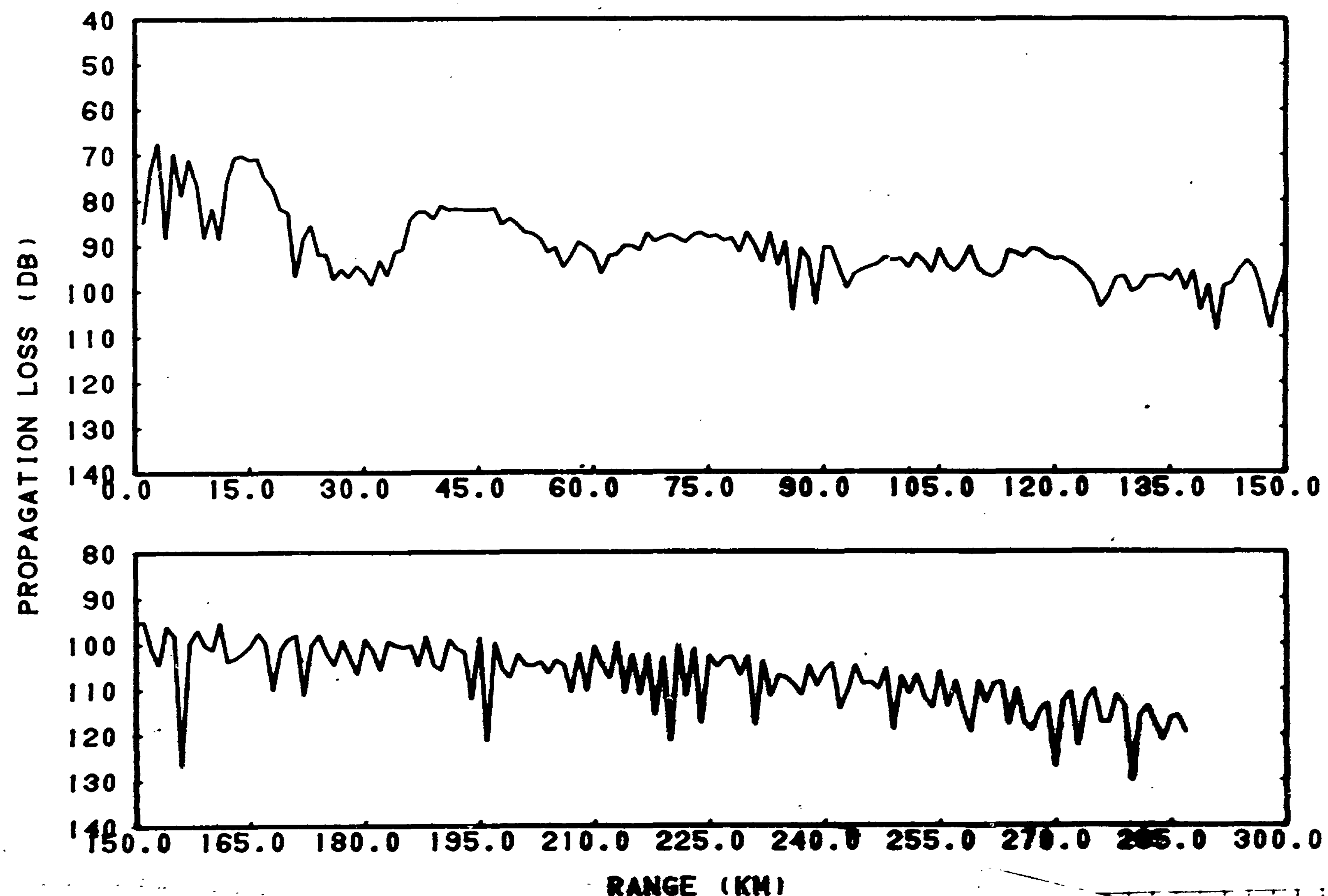
CONFIDENTIAL

(C) Figure IIID-51. RAYMODE Incoherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 140 Hertz



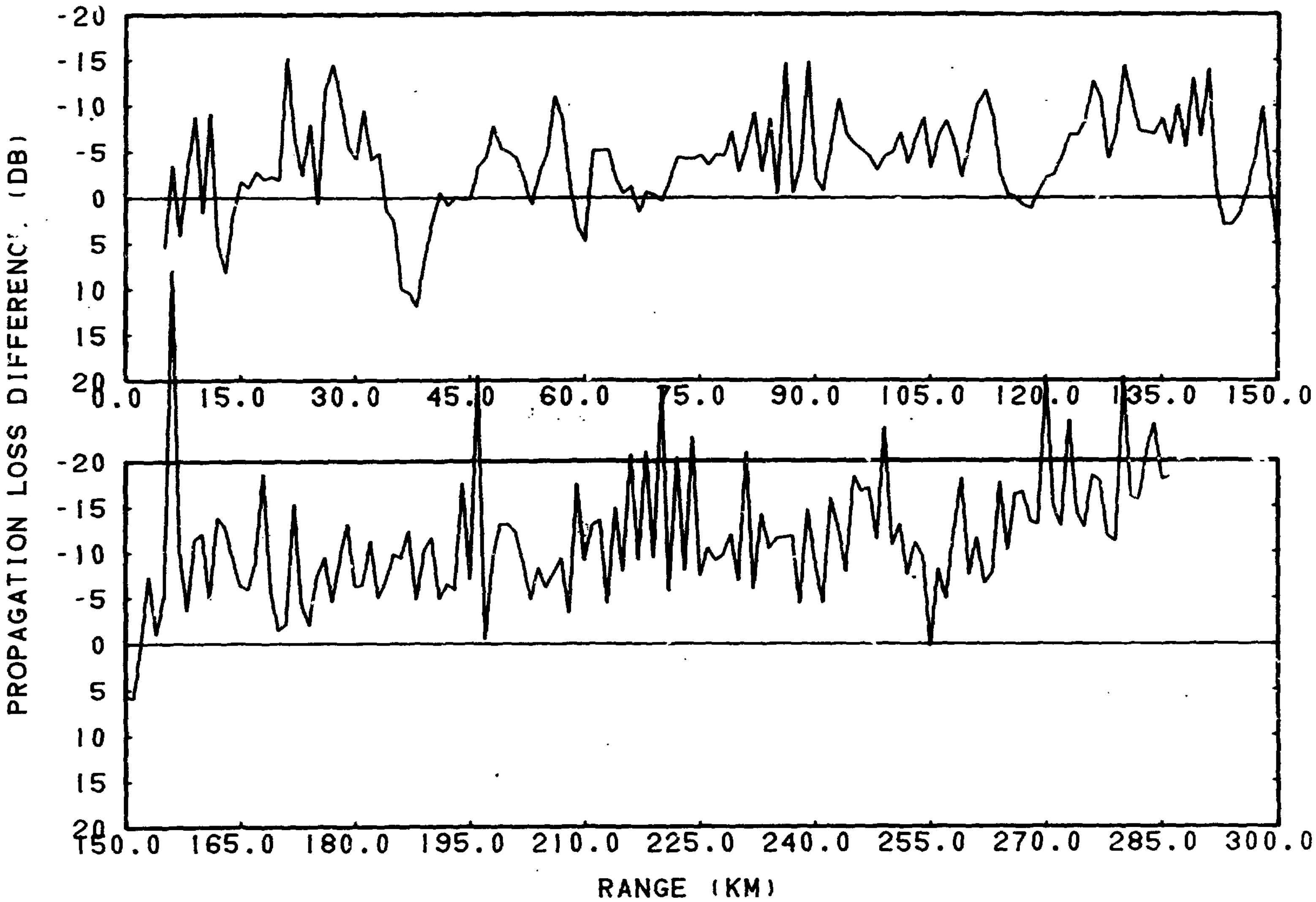
CONFIDENTIAL

(C) Figure IIID-52. RAYMODE Incoherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 140 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 140 Hertz



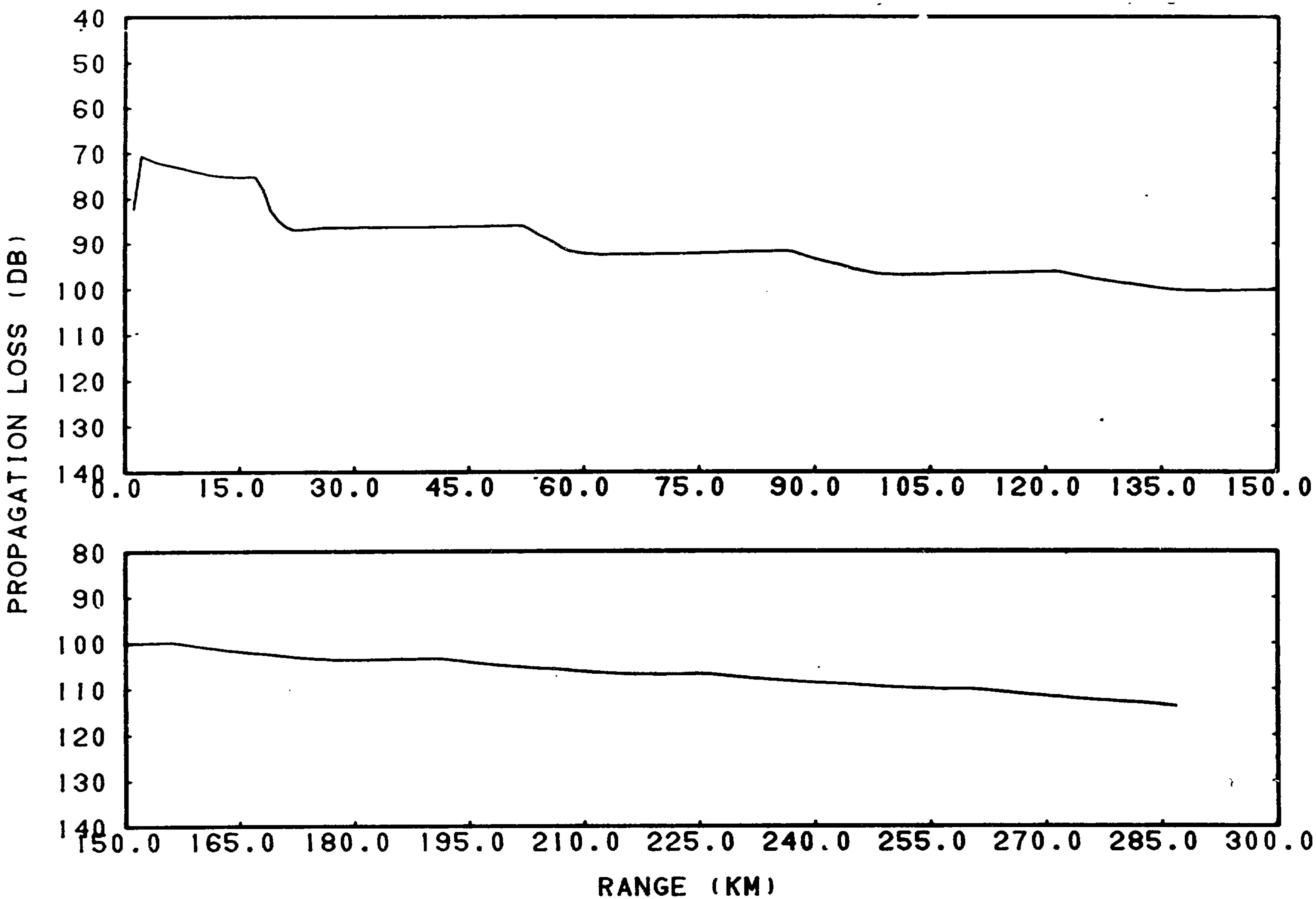
CONFIDENTIAL

(C) Figure IIID-53. RAYMODE Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 140 Hertz



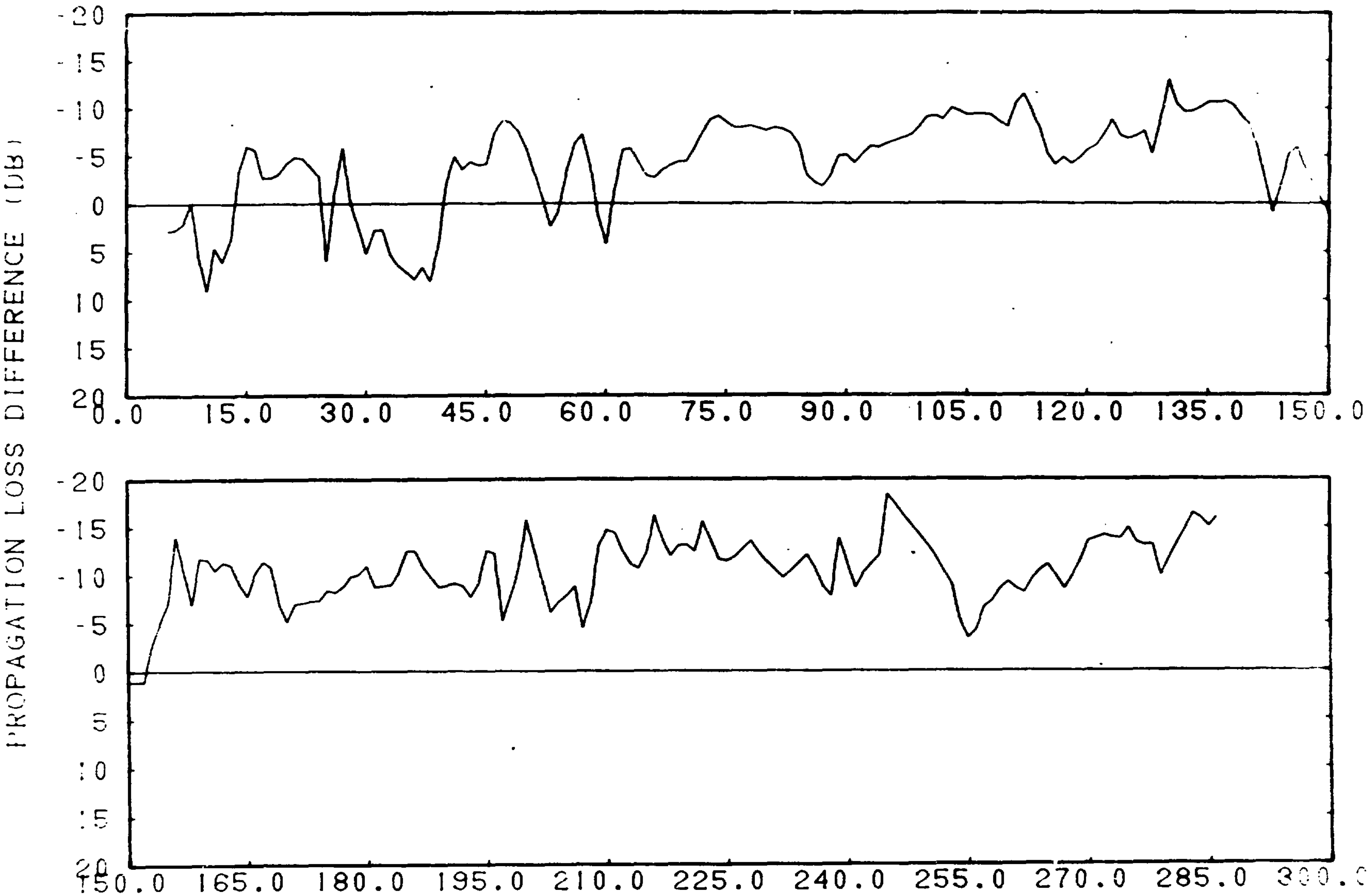
CONFIDENTIAL

(C) Figure IIID-54. RAYMODE Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 140 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 140 Hertz



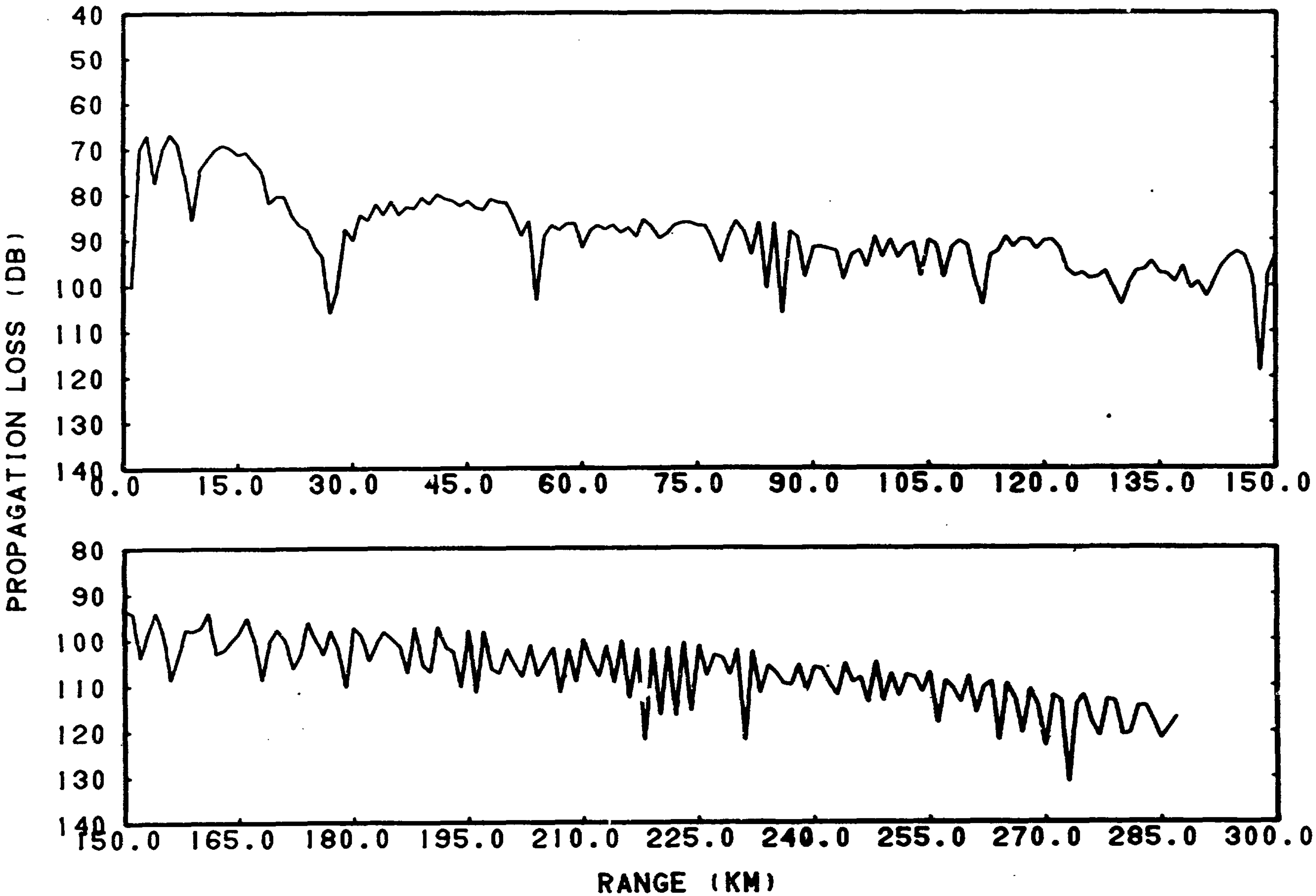
CONFIDENTIAL

(C) Figure IIID-55. RAYMODE Incoherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 140 Hertz



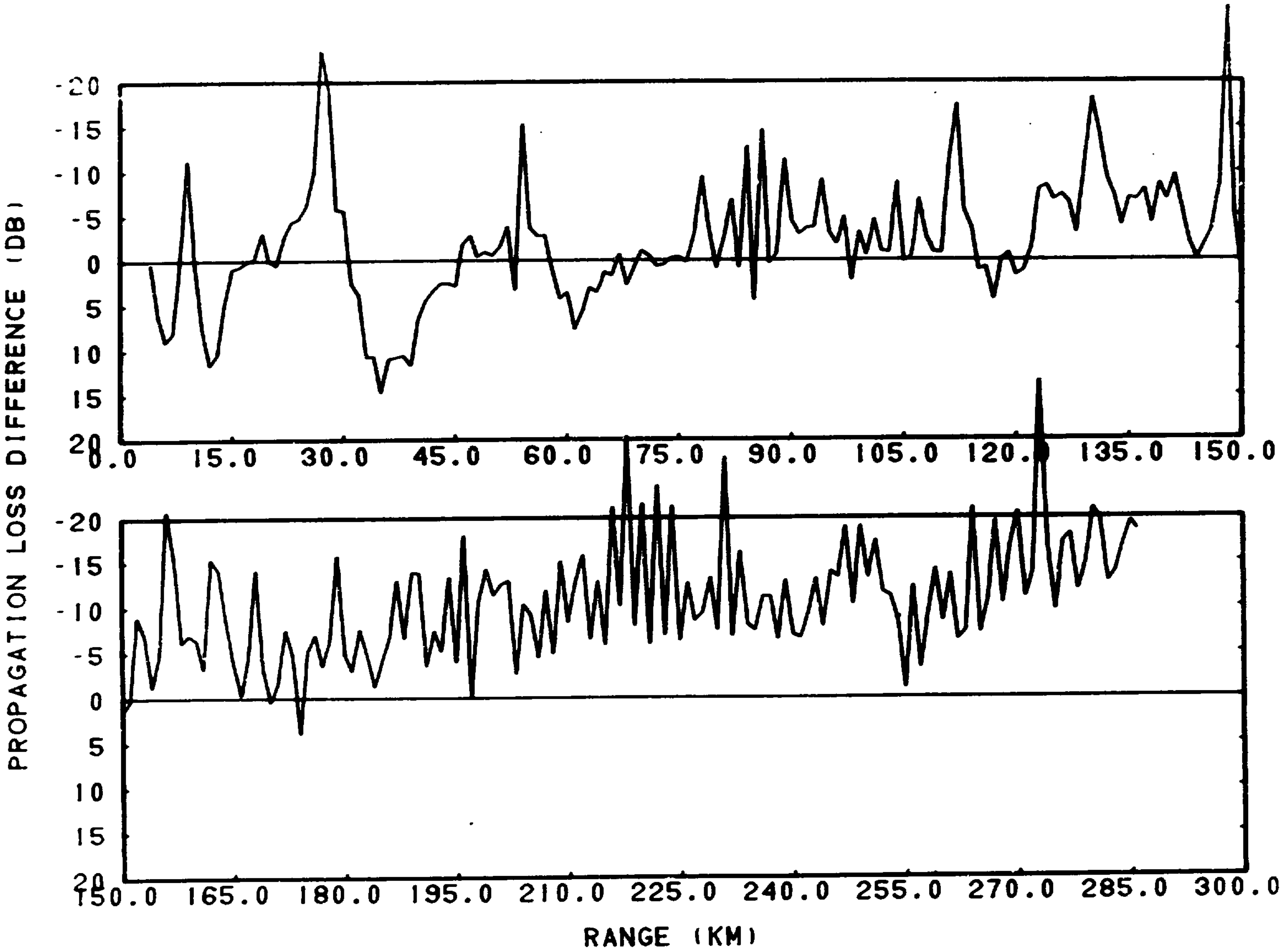
CONFIDENTIAL

(C) Figure IIID-56. RAYMODE Incoherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 140 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 140 Hertz



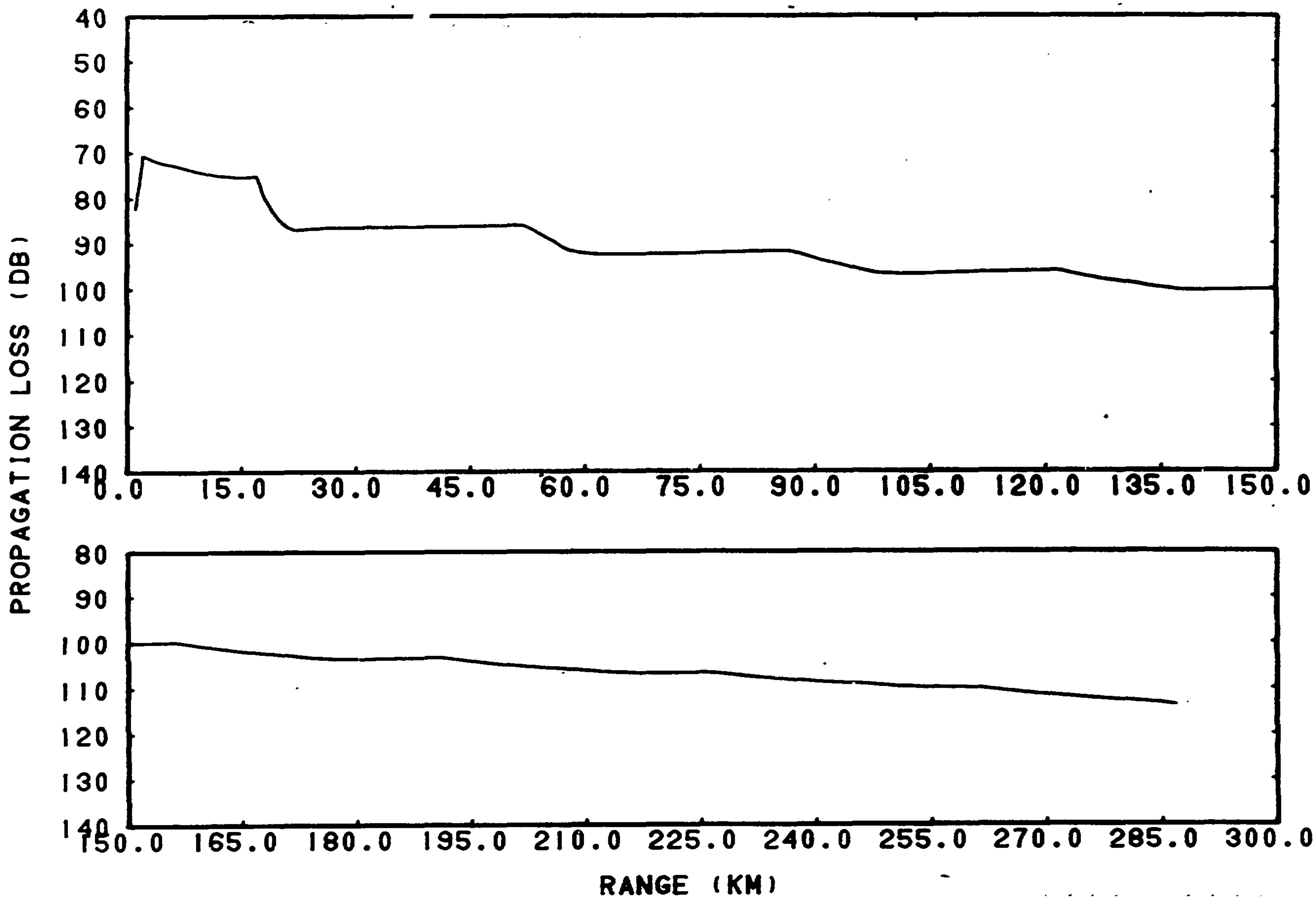
CONFIDENTIAL

(C) Figure IIID-57. RAYMODE Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 140 Hertz



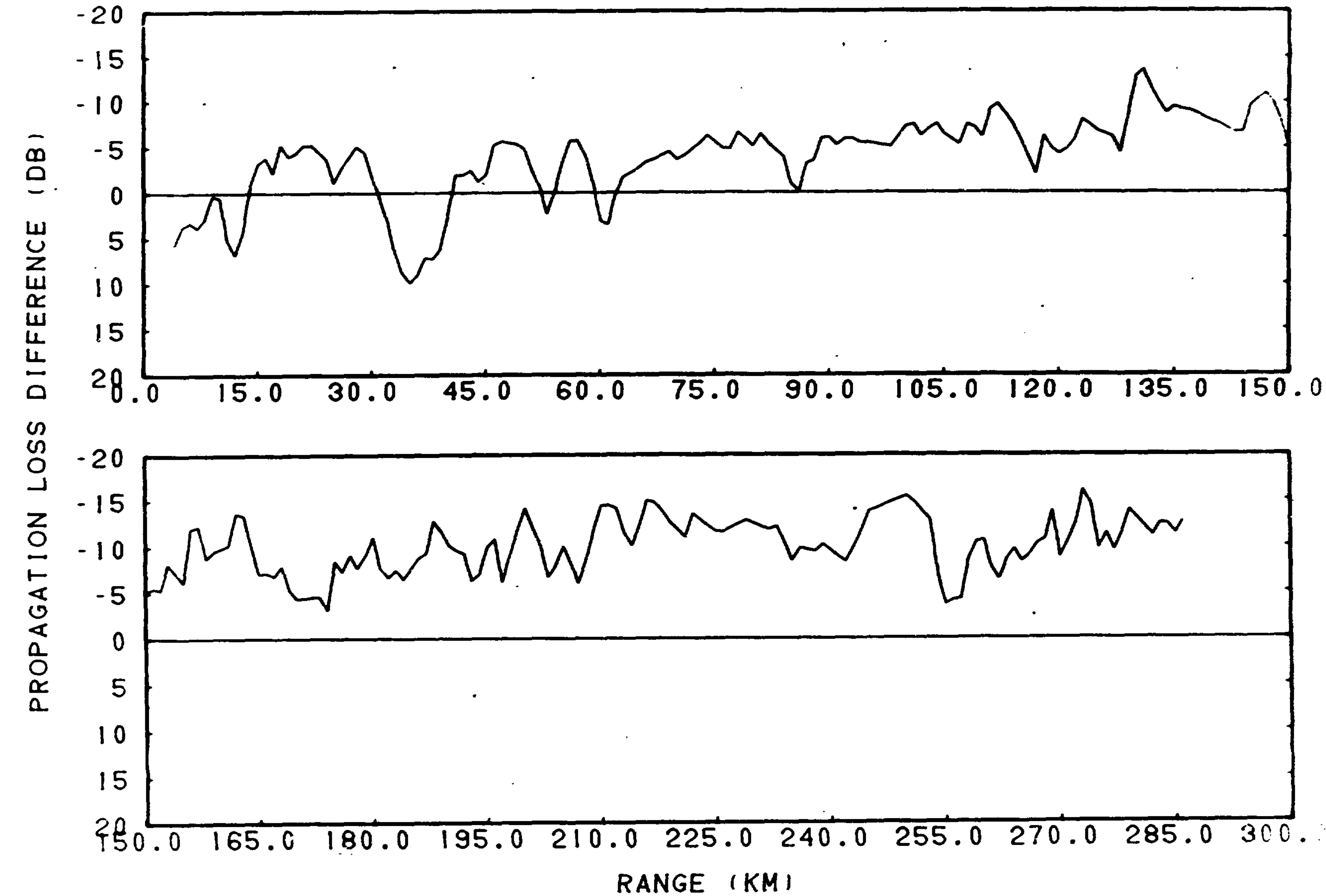
CONFIDENTIAL

(C) Figure IIID-58. RAYMODE Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 140 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 140 Hertz



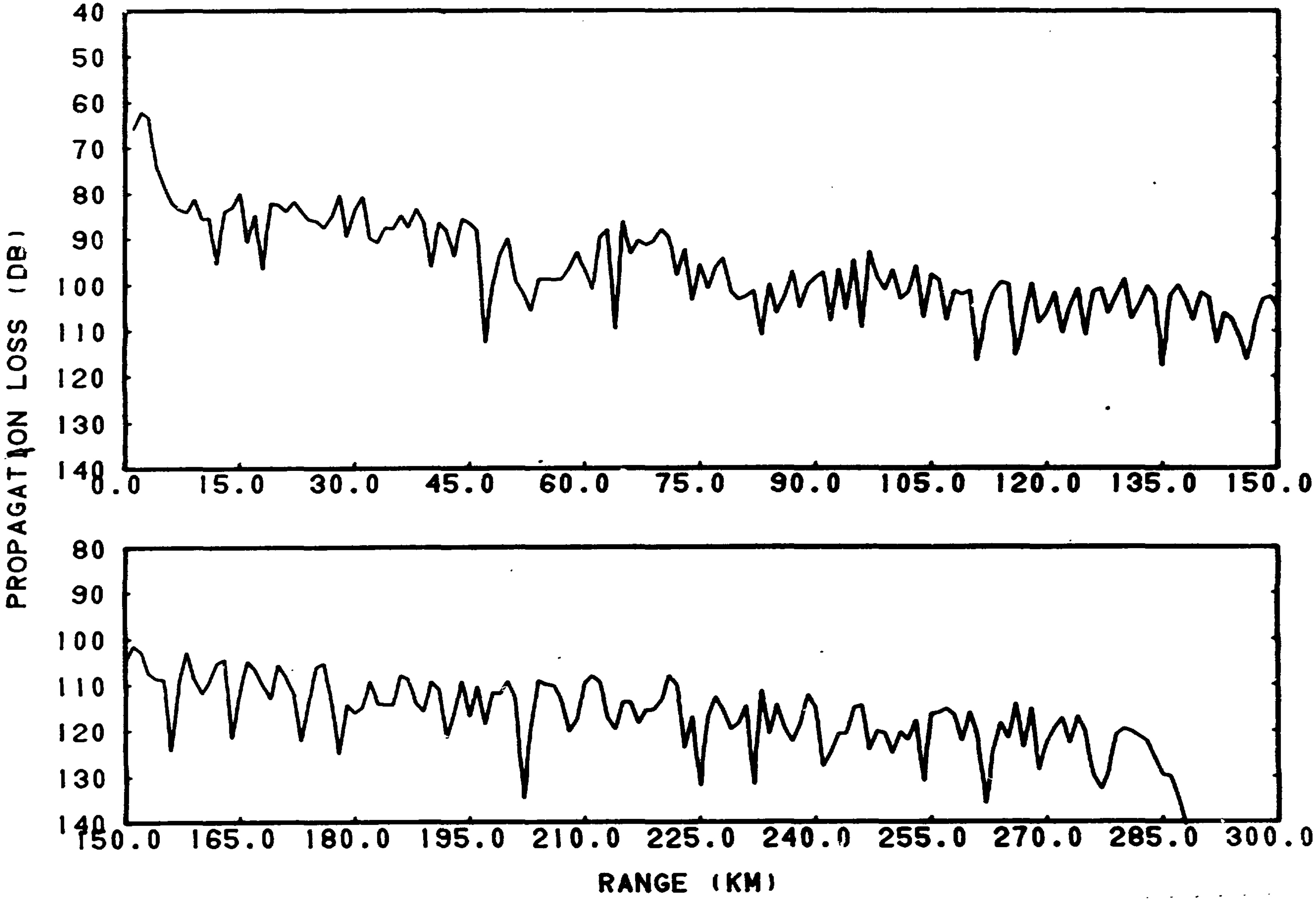
CONFIDENTIAL

(C) Figure IIID 59. RAYMODE Incoherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 140 Hertz



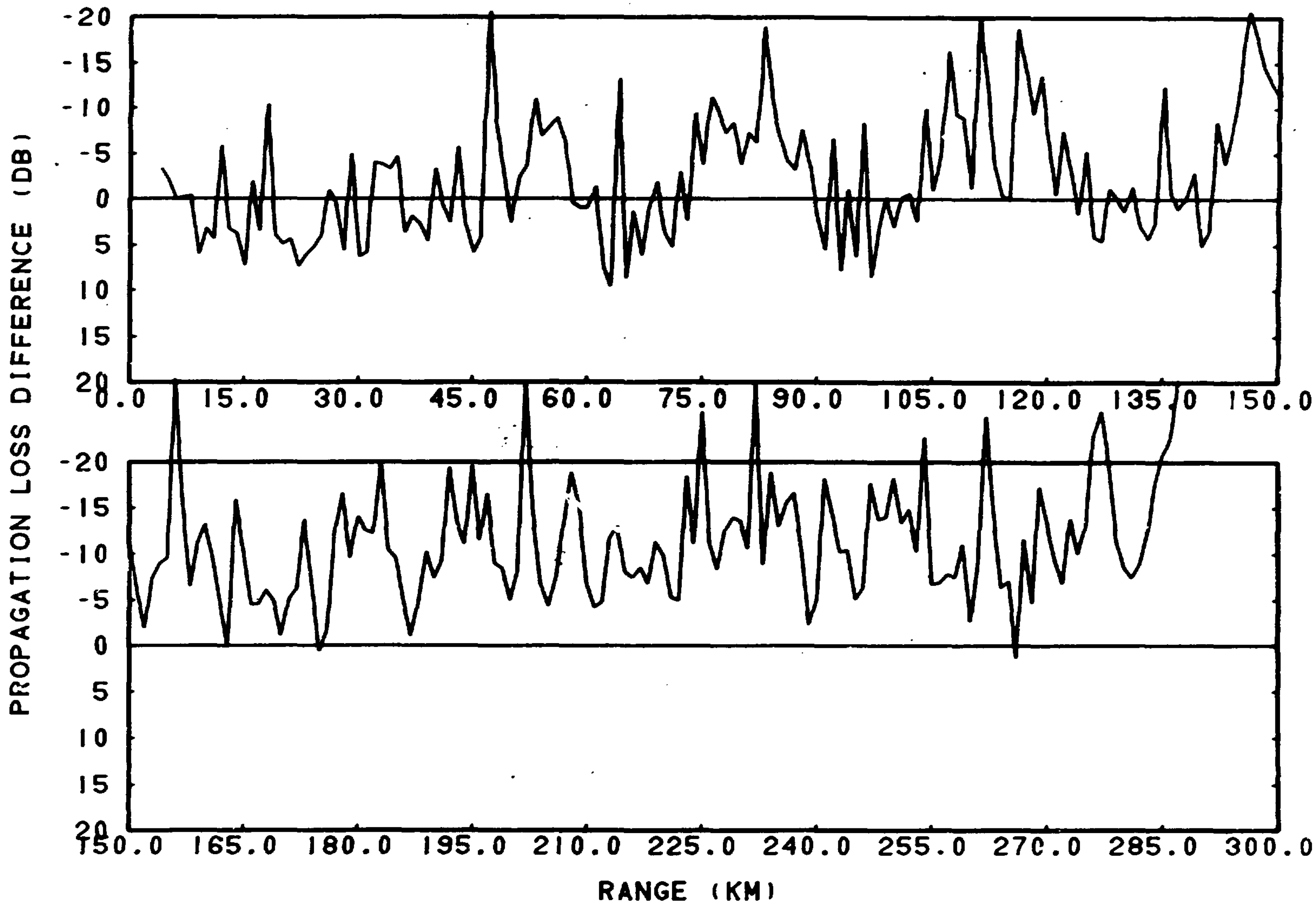
CONFIDENTIAL

(C) Figure IIID-60. RAYMODE Incoherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 140 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 140 Hertz



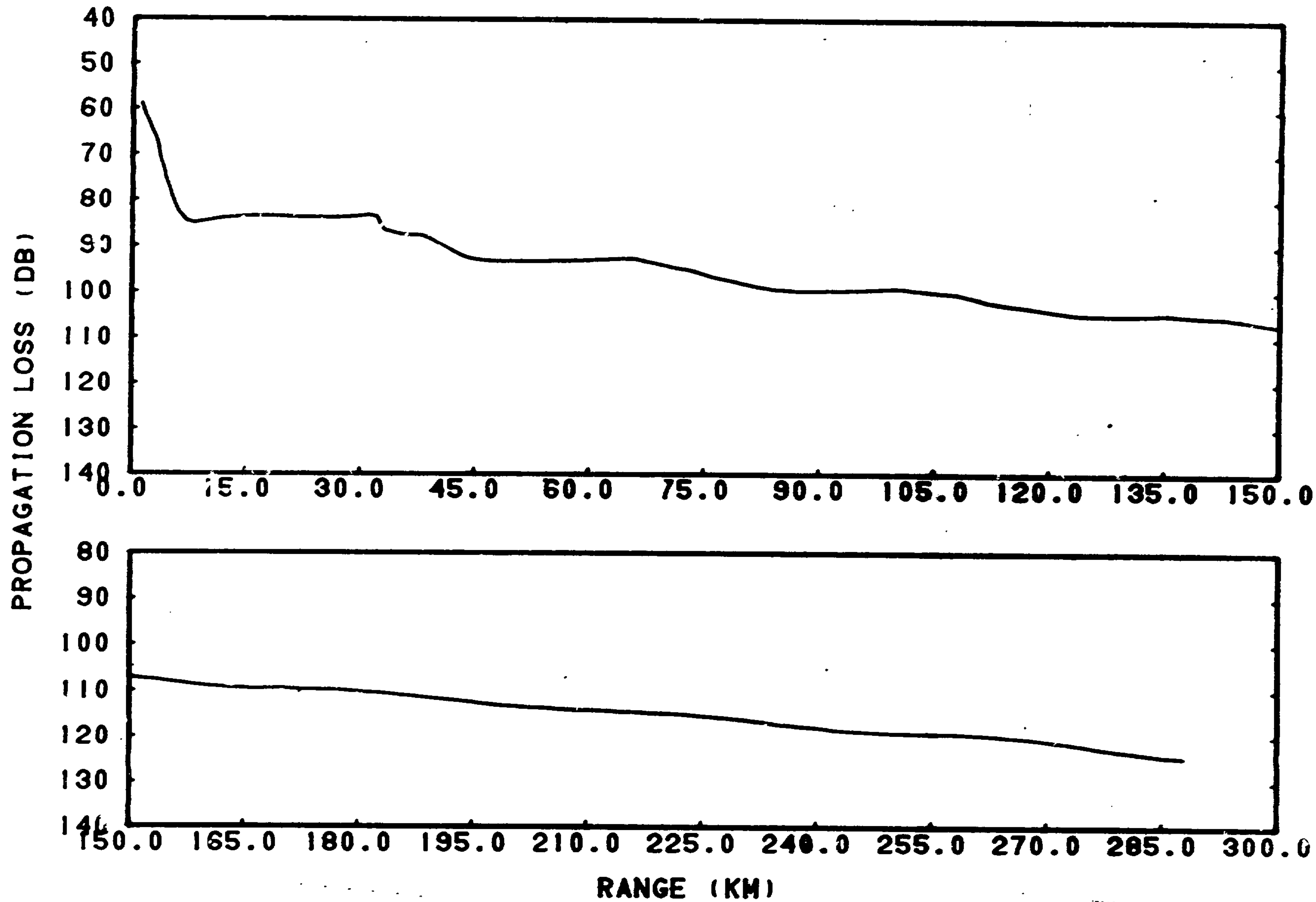
CONFIDENTIAL

(C) Figure IIID-61. RAYMODE Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 290 Hertz



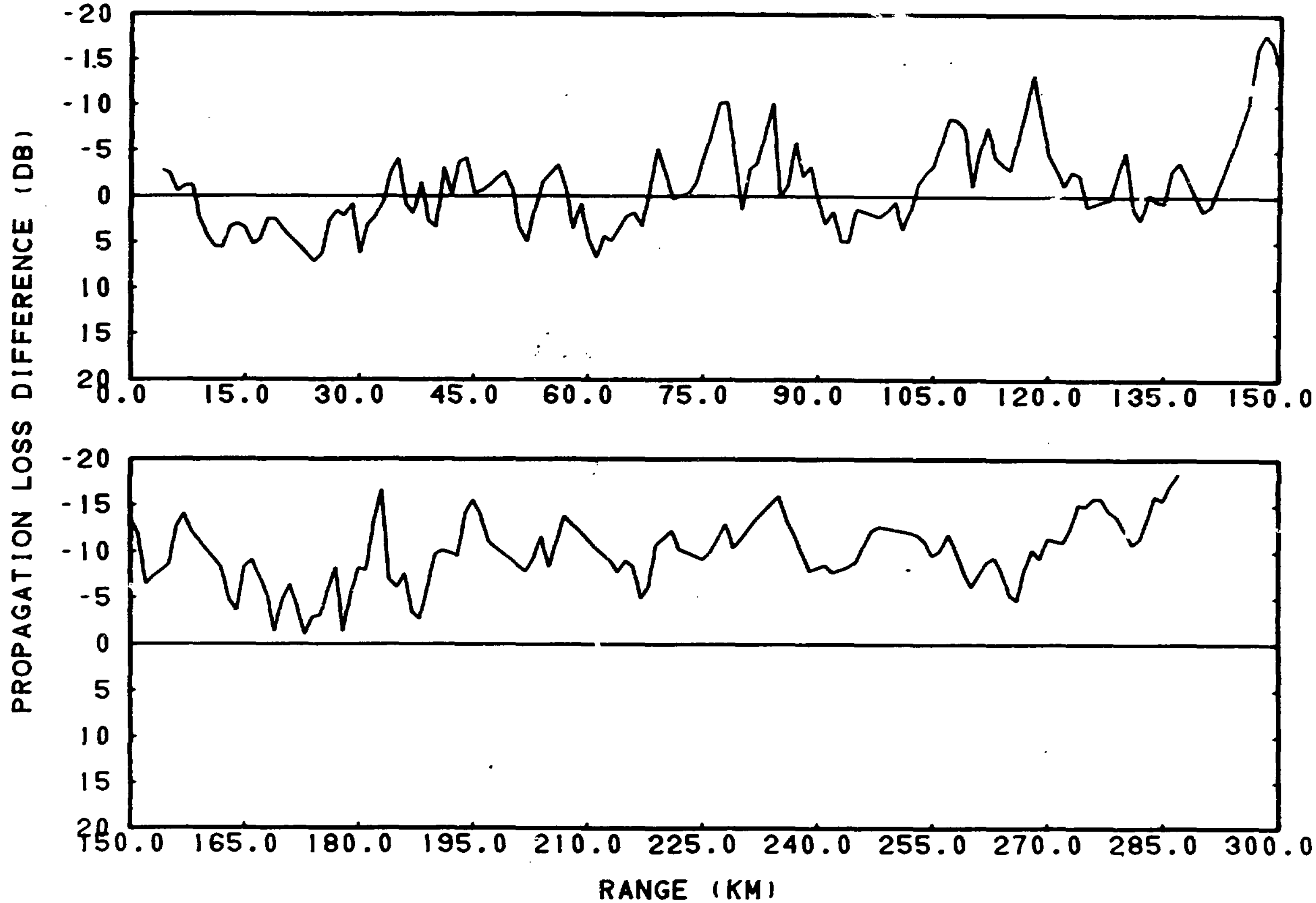
CONFIDENTIAL

(C) Figure IIID-62. RAYMODE Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 2"1 Hertz, Subtracted from Smoothed Bearing Stake Sta. on 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 290 Hertz



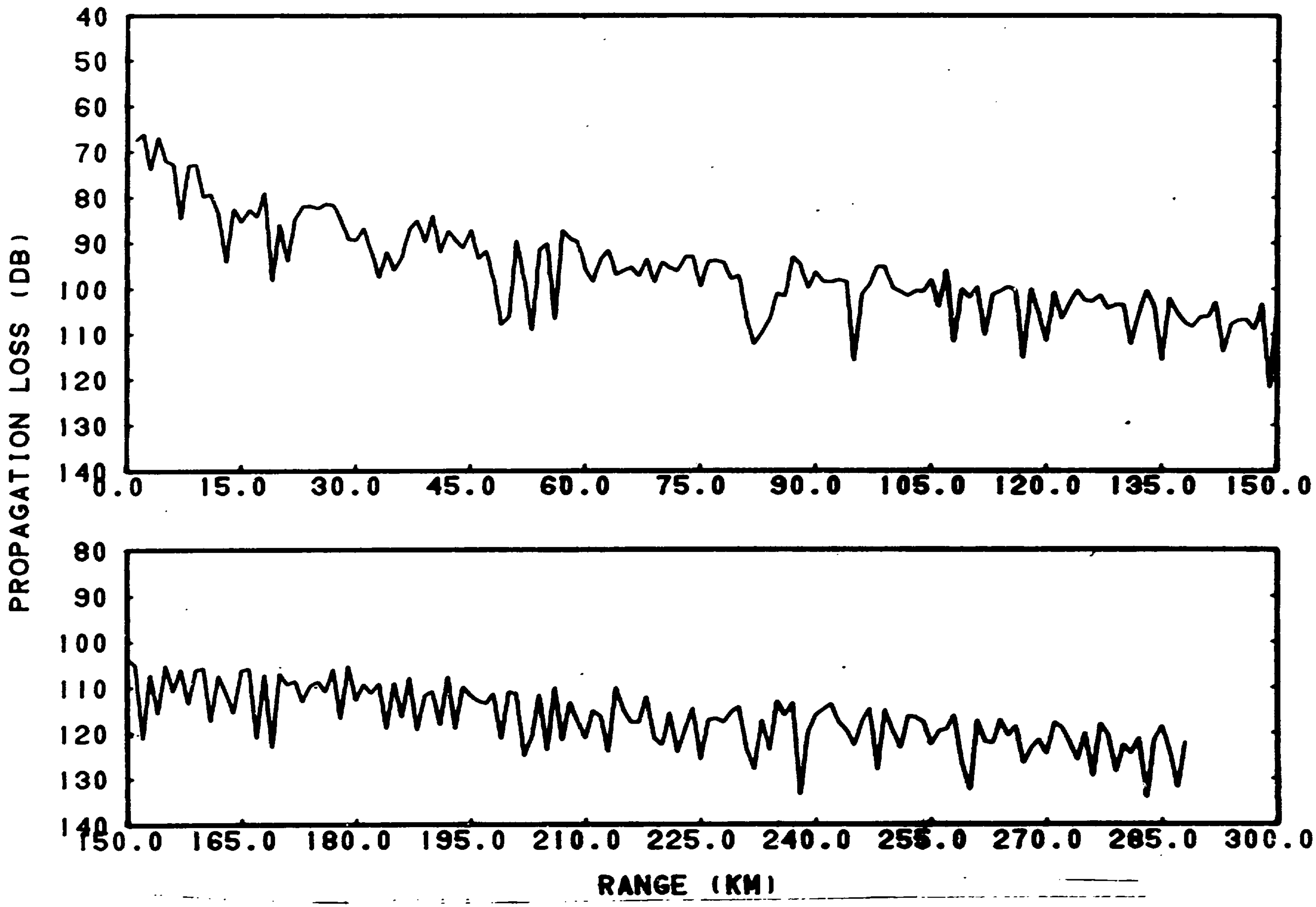
CONFIDENTIAL

(C) Figure IIID-63. RAYMODE Incoherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 290 Hertz



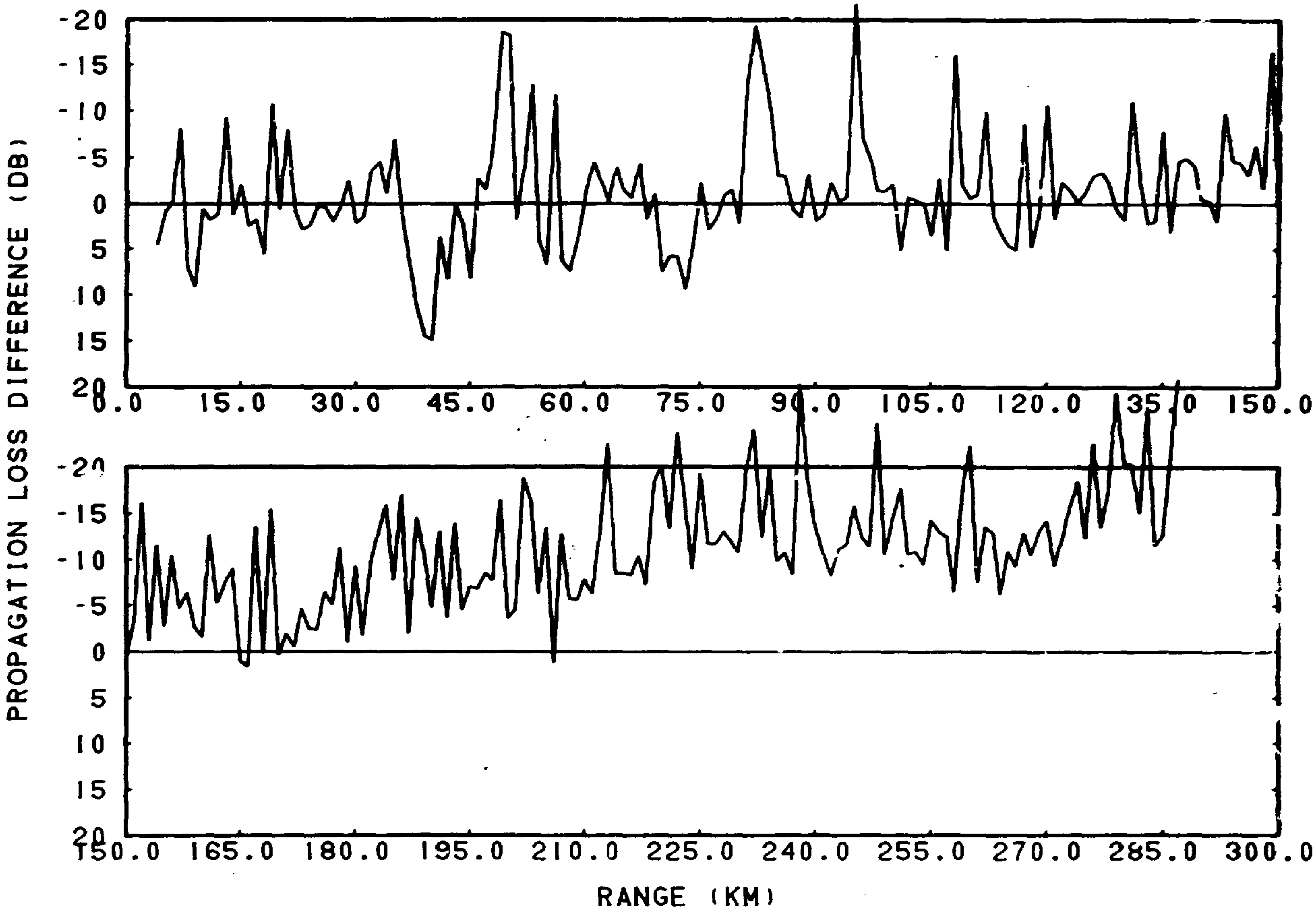
CONFIDENTIAL

(C) Figure IIID-64. RAYMODE Incoherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 290 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 496 Meters, Frequency = 290 Hertz



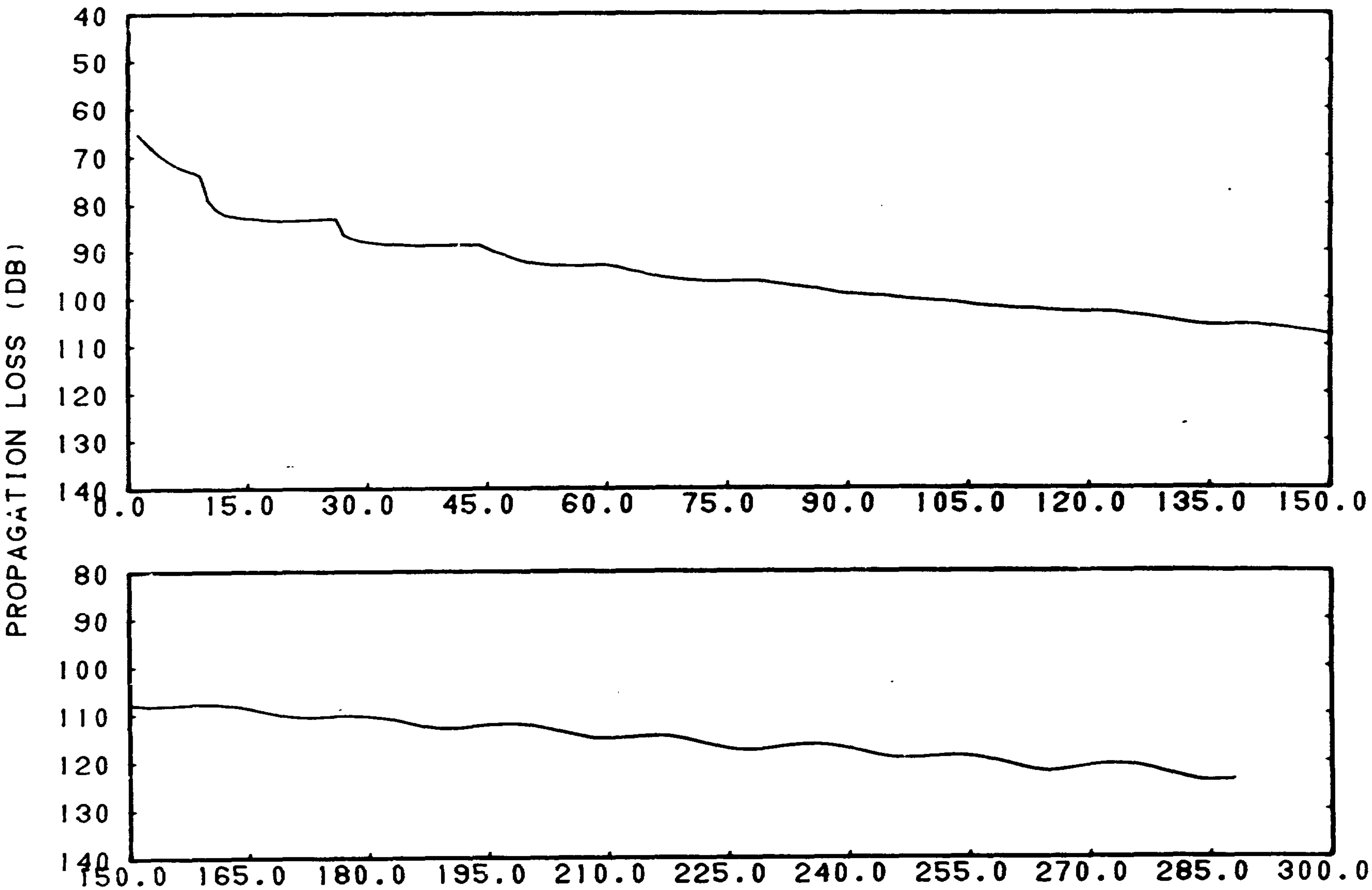
CONFIDENTIAL

(C) Figure IIID-65. RAYMODE Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 290 Hertz



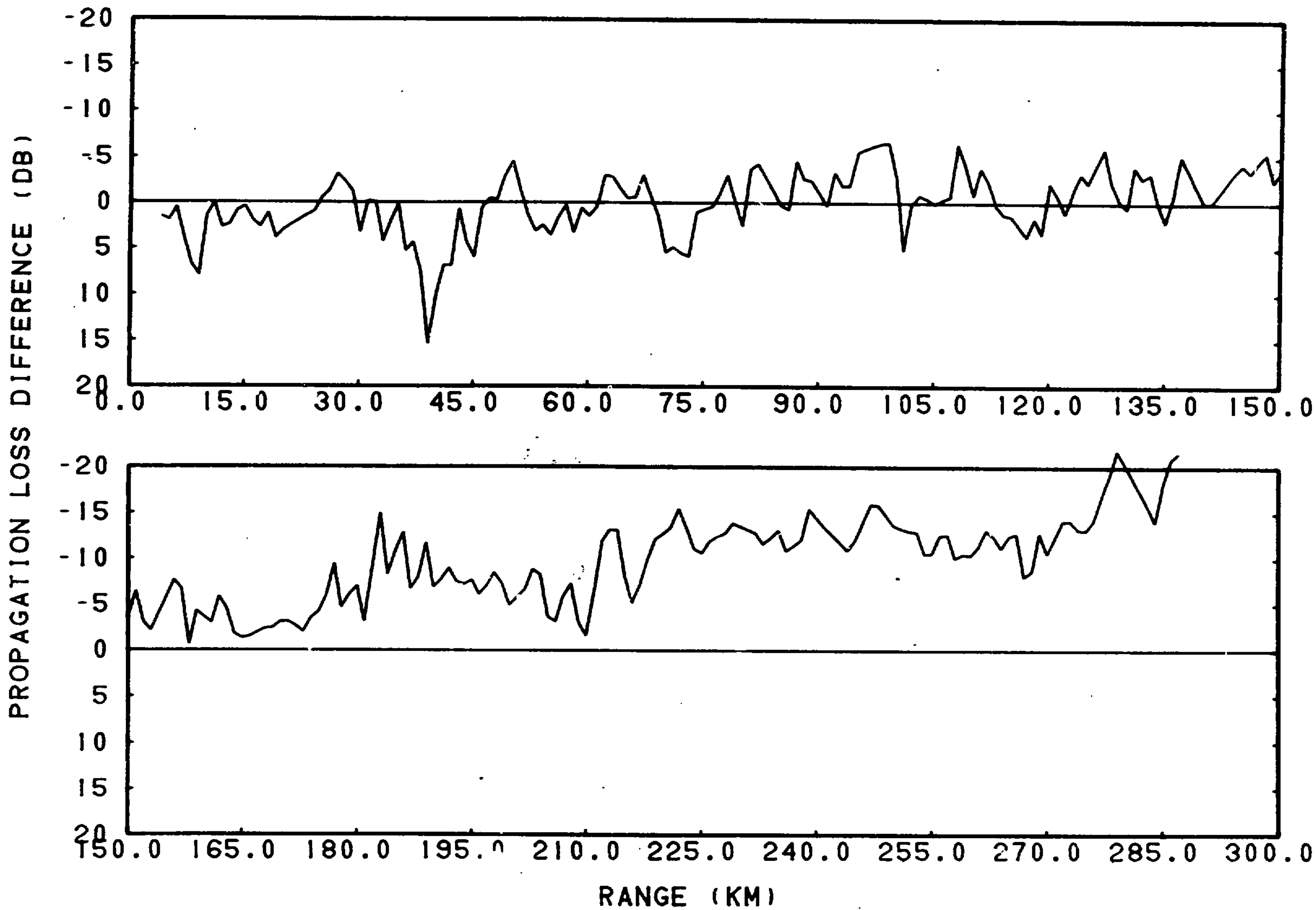
CONFIDENTIAL

(C) Figure IIID-66. RAYMODE Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 290 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 290 Hertz



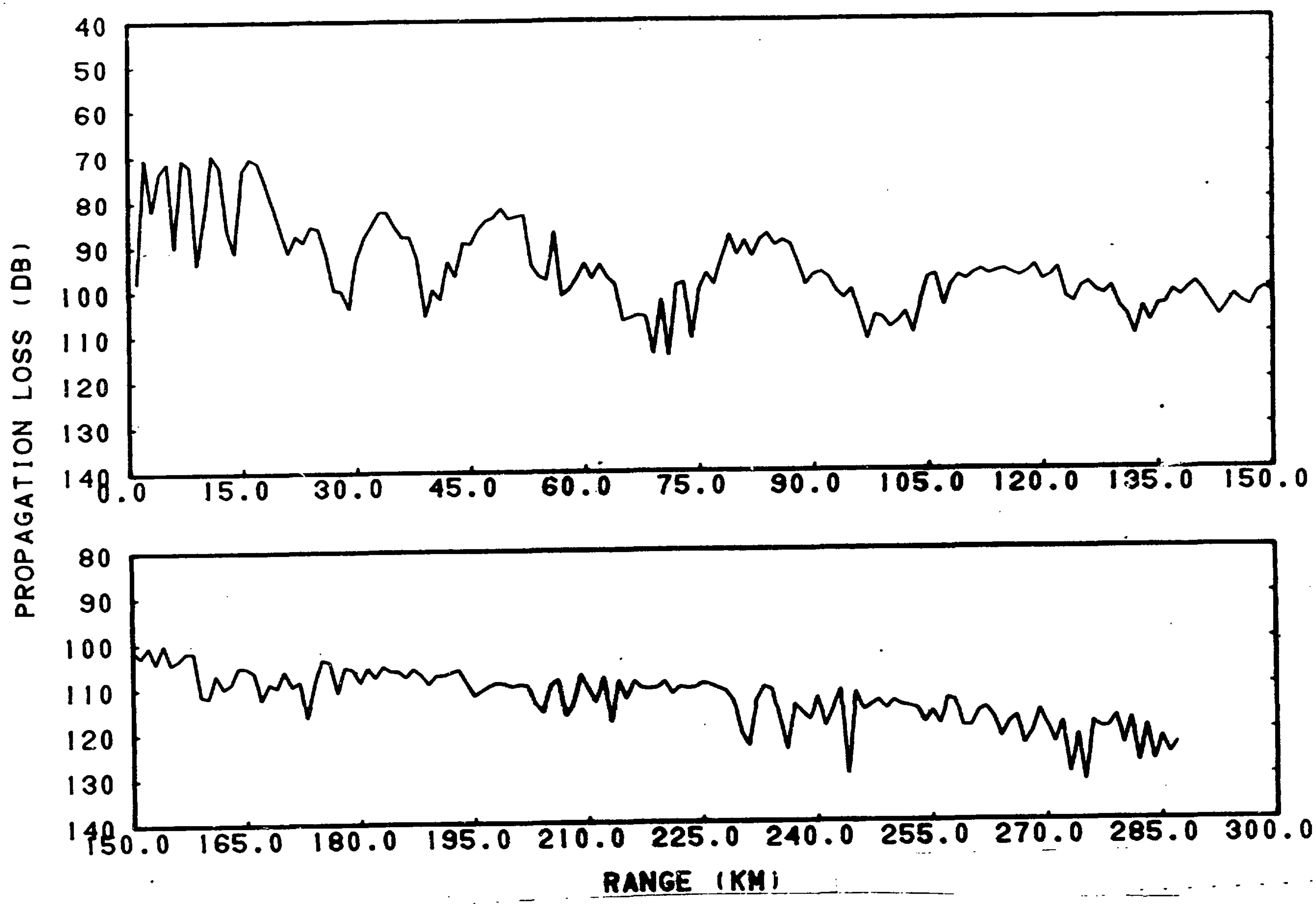
CONFIDENTIAL

(C) Figure IIID-67. RAYMODE Incoherent Station 1B, Run P1, Source Depth = 19 Meters, Receiver Depth = 1685 Meters, Frequency = 290 Hertz



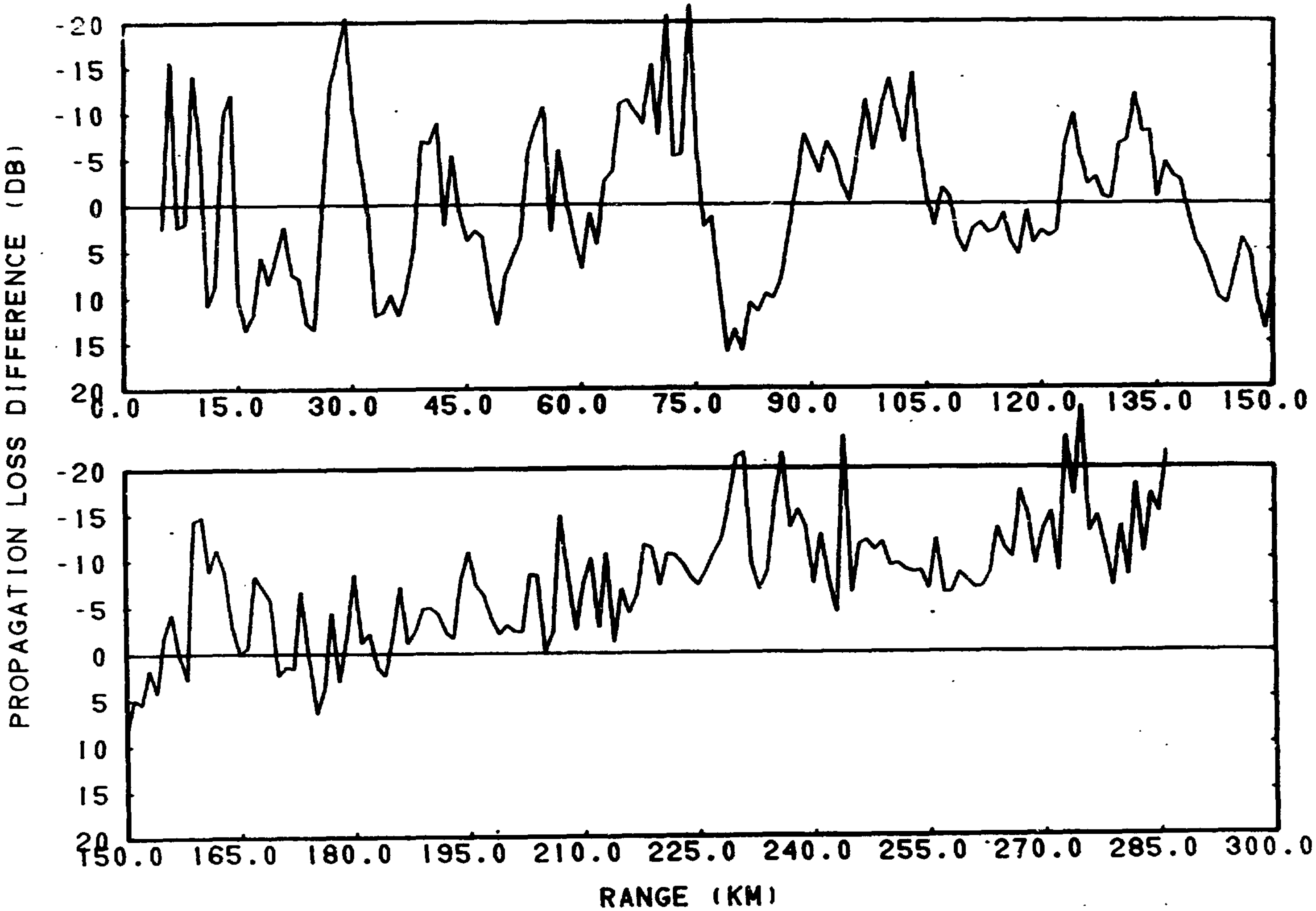
CONFIDENTIAL

(C) Figure IIID-68. RAYMODE Incoherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 290 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 1685 Meters, Frequency = 290 Hertz



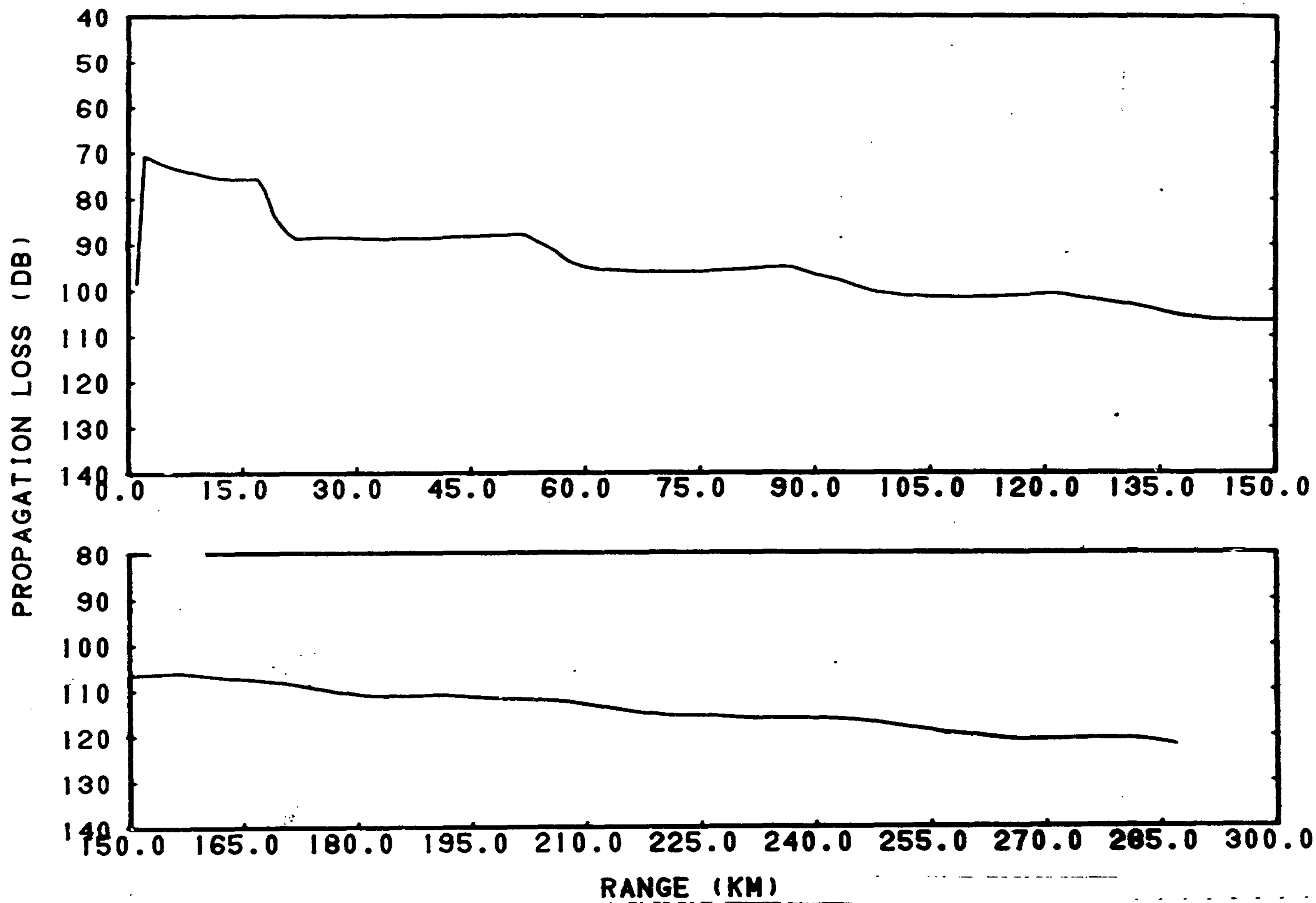
CONFIDENTIAL

(C) Figure IIID-69. RAYMODE Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 290 Hertz



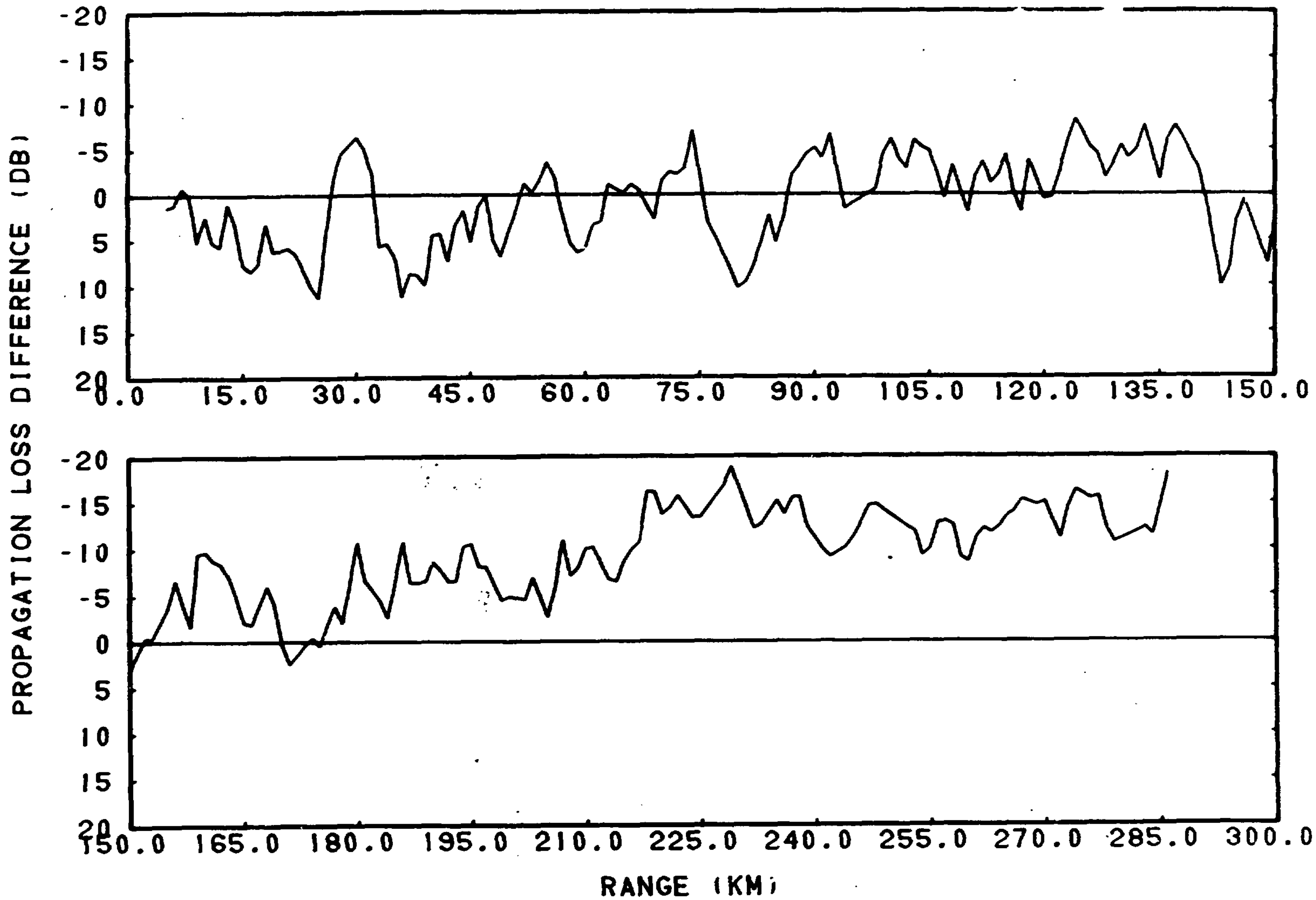
CONFIDENTIAL

(C) Figure IIID-70. RAYMODE Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 290 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver 3320 Meters, Frequency = 290 Hertz



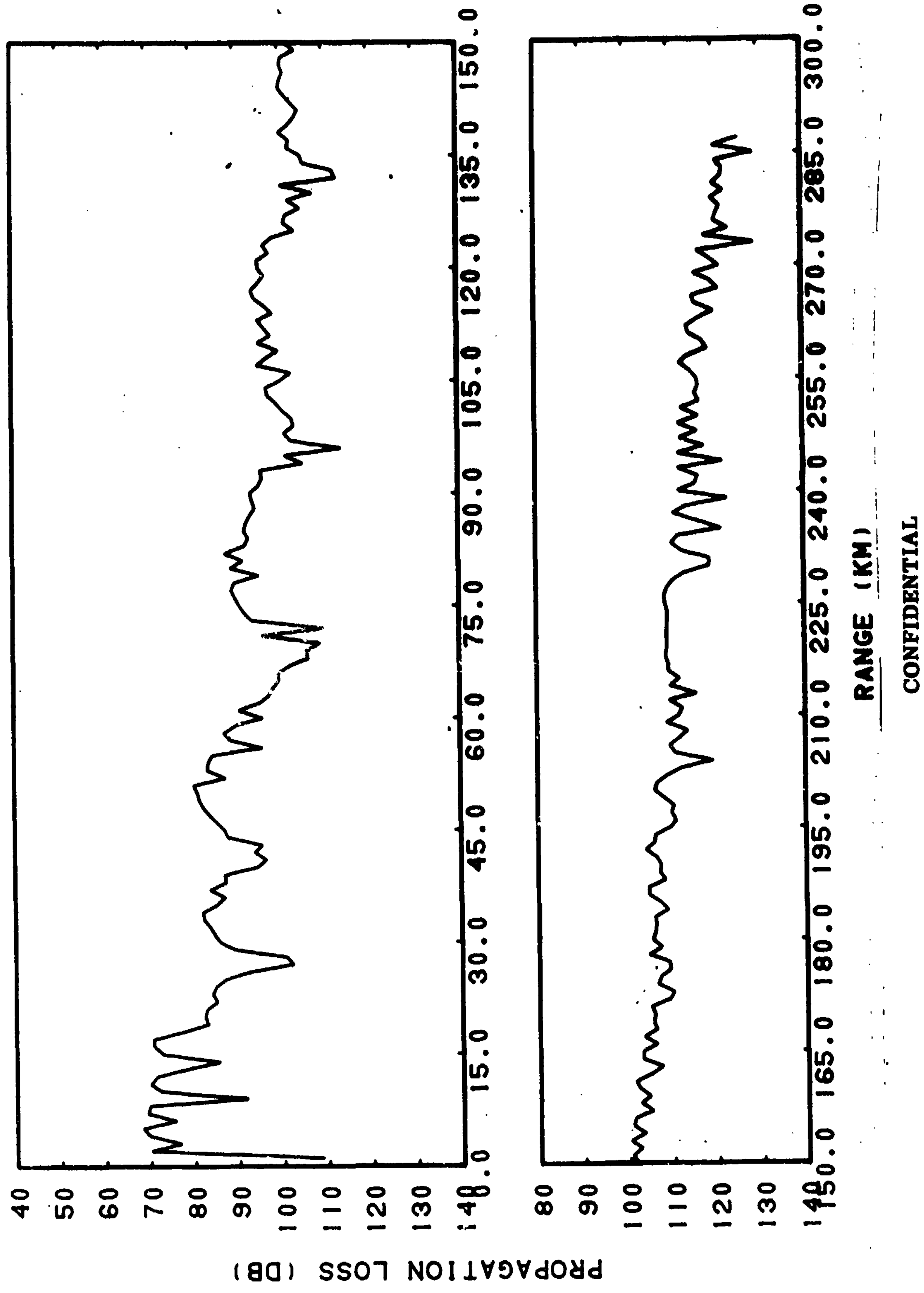
CONFIDENTIAL

(C) Figure IIID-71. RAYMODE Incoherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 290 Hertz

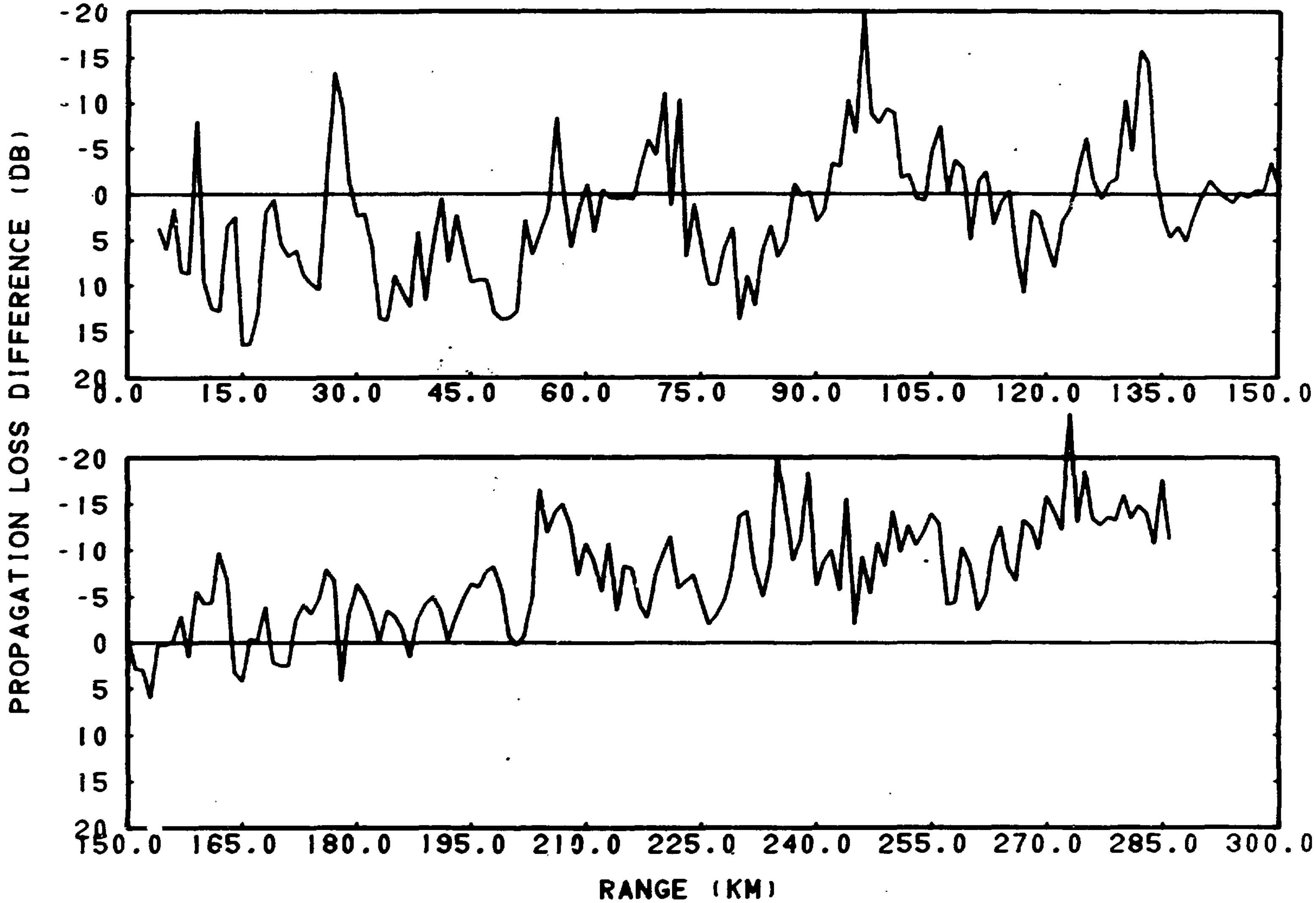


CONFIDENTIAL

(C) Figure IIID-72. RAYMODE Incoherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 290 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3320 Meters, Frequency = 290 Hertz

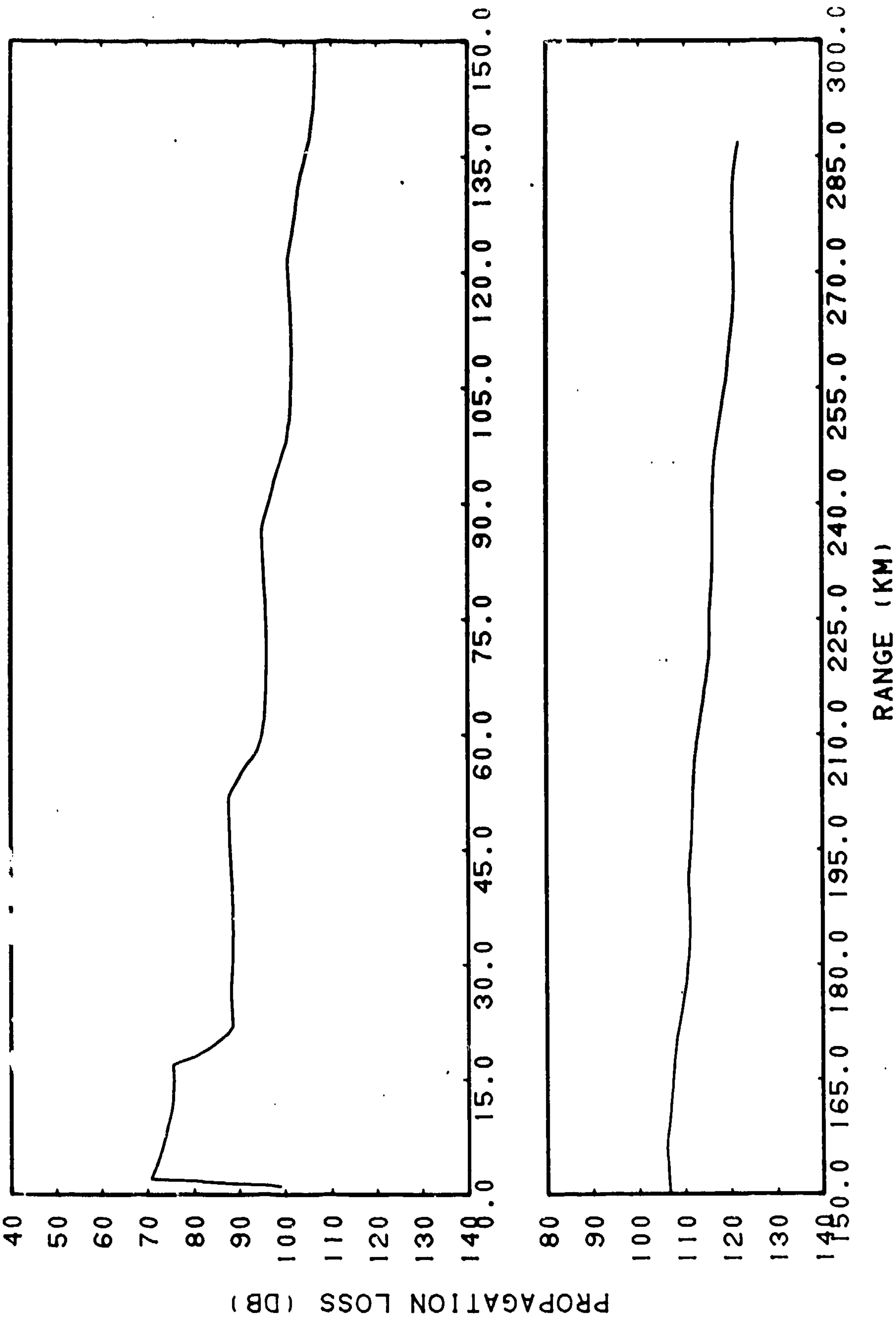


(C) Figure IIID-73. RAYMODE Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 290 Hertz



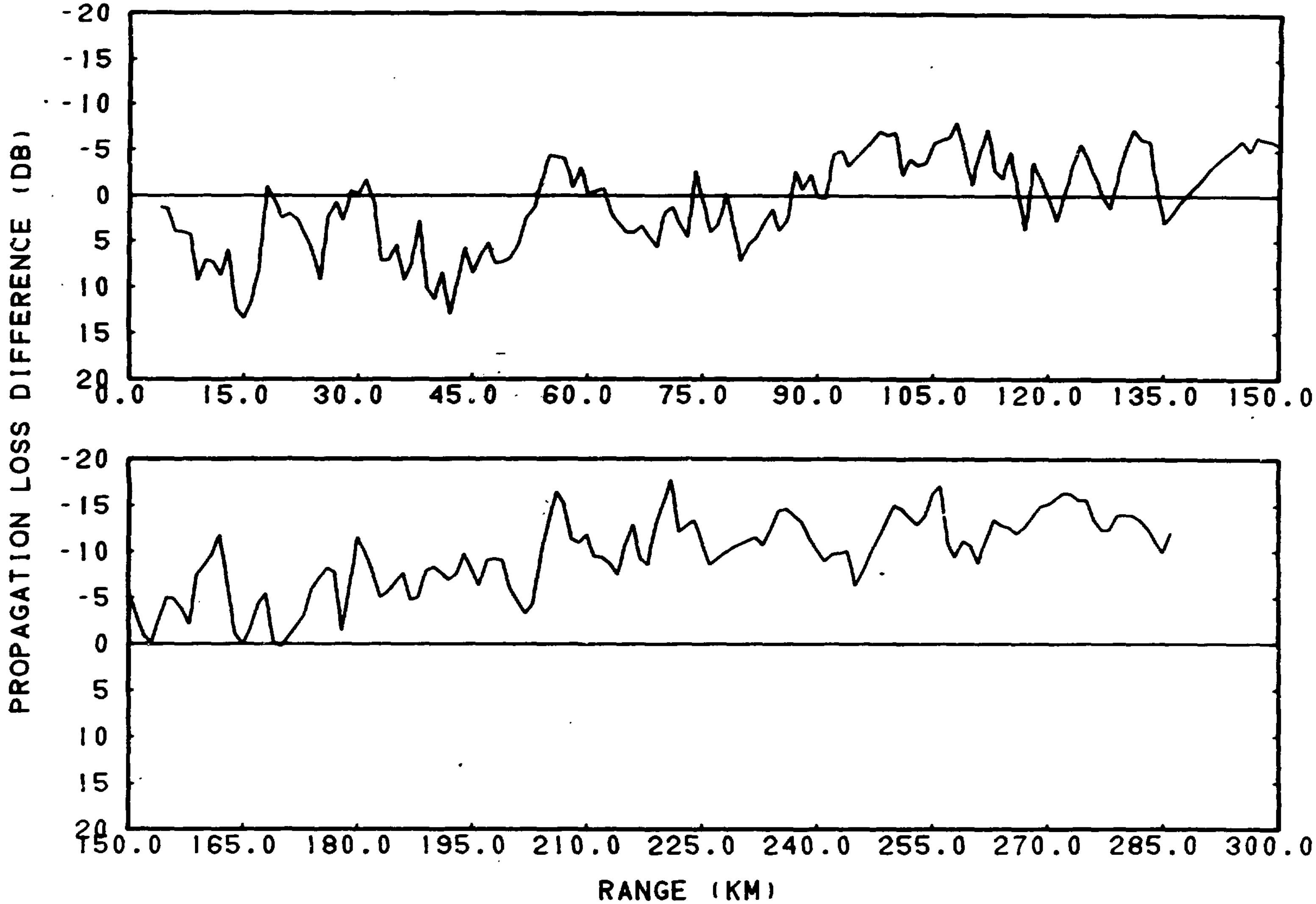
CONFIDENTIAL

(C) Figure IIID-74. RAYMODE Coherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 290 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 290 Hertz



CONFIDENTIAL

(C) Figure IIID-75. RAYMODE Incoherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 290 Hertz



CONFIDENTIAL

(C) Figure IIID-76. RAYMODE Incoherent Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 290 Hertz, Subtracted from Smoothed Bearing Stake Station 1B, Run P1, Source Depth = 18 Meters, Receiver Depth = 3350 Meters, Frequency = 290 Hertz

DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
800 NORTH QUINCY STREET
ARLINGTON, VA 22217-5660

IN REPLY REFER TO
5510/1
Ser 93/160
10 Mar 99

From: Chief of Naval Research
To: Commander, Naval Meteorology and Oceanography Command
1020 Balch Boulevard
Stennis Space Center MS 39529-5005

Subj: DECLASSIFICATION OF PARKA I AND PARKA II REPORTS

Ref: (a) CNMOC ltr 3140 Ser 5/110 of 12 Aug 97

Encl: (1) Listing of Known Classified PARKA Reports

1. In response to reference (a), the Chief of Naval Operations (N874) has reviewed a number of Pacific Acoustic Research Kaneohe-Alaska (PARKA) Experiment documents and has determined that all PARKA I and PARKA II reports may be declassified and marked as follows:

   Classification changed to UNCLASSIFIED by authority of Chief of Naval Research letter Ser 93/160, 10 Mar 99.

   DISTRIBUTION STATEMENT A: Approved for public release. Distribution is unlimited.

2. Enclosure (1) is a listing of known classified PARKA reports. The marking on those documents should be changed as noted in paragraph 1 above. When other PARKA I and PARKA II reports are identified, their markings should be changed and a copy of the title page and a notation of how many pages the document contained should be provided to Chief of Naval Research (ONR 93), 800 N. Quincy Street, Arlington, VA 22217-5660. This will enable me to maintain a master list of downgraded PARKA reports.

3. Questions may be directed to the undersigned on (703) 696-4619, DSN 426-4619.

Peggy Lambert

PEGGY LAMBERT
By direction

Copy to:
NUWC Newport Technical Library (Code 5441)
NRL Washington (Mary Templeman, Code 5227)
NRL SSC (Roger Swanton, Code 7031)
✓DTIC (Bill Bush, DTIC-OCQ)

The Acoustic Model Evaluation Committee (AMEC) Reports, Volume 2, The Evaluation of the Fact PL9D Transmission Loss Model, Book 3, Appendices E-H, September 1982, NORDA-35-VOL-2-BK-3, 428 pages
(DTIC # C034 020)

The Acoustic Model Evaluation Committee (AMEC) Reports, Volume 3, The Evaluation of the RAYMODE X Propagation Loss Model, Book 1, September 1982, NORDA-36-VOL-3-BK-1, 127 pages
(DTIC # C034 021)

The Acoustic Model Evaluation Committee (AMEC) Reports, Volume 3, TheEvaluation of the RAYMODE X Propagation Loss Model, Book 2, Appendices A-D, September 1982, NORDA-36-VOL-3-BK-2, 324 pages
(DTIC # C034 022)

The Acoustic Model Evaluation Committee (AMEC) Reports, Volume 3, The Evaluation of the RAYMODE X Propagation Loss Model, Book 3, Appendices E-H, September 1982, NORDA-36-VOL-3-BK-3, 388 pages
(DTIC # C034 023)

DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
875 NORTH RANDOLPH STREET
SUITE 1425
ARLINGTON VA 22203-1995

IN REPLY REFER TO:

5510/1
Ser 321OA/011/06
31 Jan 06

MEMORANDUM FOR DISTRIBUTION LIST

Subj: DECLASSIFICATION OF LONG RANGE ACOUSTIC PROPAGATION PROJECT (LRAPP) DOCUMENTS

Ref: (a) SECNAVINST 5510.36

Encl: (1) List of DECLASSIFIED LRAPP Documents

1. In accordance with reference (a), a declassification review has been conducted on a number of classified LRAPP documents.

2. The LRAPP documents listed in enclosure (1) have been downgraded to UNCLASSIFIED and have been approved for public release. These documents should be remarked as follows:

   Classification changed to UNCLASSIFIED by authority of the Chief of Naval Operations (N772) letter N772A/6U875630, 20 January 2006.

   DISTRIBUTION STATEMENT A: Approved for Public Release; Distribution is unlimited.

3. Questions may be directed to the undersigned on (703) 696-4619, DSN 426-4619.

BRIAN LINK
By direction

Subj: DECLASSIFICATION OF LONG RANGE ACOUSTIC PROPAGATION PROJECT (LRAPP) DOCUMENTS

DISTRIBUTION LIST:

NAVOCEANO (Code N121LC – Jaime Ratliff)
NRL Washington (Code 5596.3 – Mary Templeman)
PEO LMW Det San Diego (PMS 181)
DTIC-OCQ (Larry Downing)
ARL, U of Texas
Blue Sea Corporation (Dr.Roy Gaul)
ONR 32B (CAPT Paul Stewart)
ONR 321OA (Dr. Ellen Livingston)
APL, U of Washington
APL, Johns Hopkins University
ARL, Penn State University
MPL of Scripps Institution of Oceanography
WHOI
NAVSEA
NAVAIR
NUWC
SAIC

Declassified LRAPP Documents

Report Number	Personal Author	Title	Publication Source (Originator)	Pub. Date	Current Availability	Class.
NORDA35VOL.1BK 2OF3	Lauer, R.B.	THE ACOUSTIC MODEL EVALUATION COMMITTEE (AMEC) REPORTS, VOL. 2- APPENDICES A-D- EVALUATION OF THE FACT PL9D TRANSMISSION LOSS MODEL	Naval Ocean R&D Activity	810901	ND ADC034014	U
NORDA36VOL.3BK 2OF3	Lauer, R.B., et al.	THE ACOUSTIC MODEL EVALUATION COMMITTEE (AMEC) REPORTS, VOL. 3- APPENDICES A-D- EVALUATION OF THE RAYMODE X PROPAGATION LOSS MODEL (U)	Naval Ocean R&D Activity	810901	ND ADC034022	U
Unavailable	Hooper, M. W., et al.	MEASUREMENTS AND ANALYSIS OF ACOUSTIC BOTTOM INTERACTION IN THE NORTHWESTERN MEXICAN BASIN	University of Texas, Applied Research Laboratories	811005	ADA107551	U
Unavailable	Kirby, W. D.	FINAL REPORT FOR CONTRACT NUMBER N00014-78-C-0862	Science Applications Inc.	820201	ADA111000	U
Unavailable	Brunson, B. A., et al.	PHYSICAL SEDIMENT MODEL FOR THE PREDICTION OF SEAFLOOR GEOACOUSTIC PROPERTIES	Planning Systems Inc.	820701	ADA119445	U
Unavailable	Cavanagh, R. C., et al.	NORDA PARABOLIC EQUATION WORKSHOP, 31 MARCH - 3 APRIL 1981	Naval Ocean R&D Activity	820901	ADA121932	U
NORDA34VOL.1A	Martin, R. L., et al.	THE ACOUSTIC MODEL EVALUATION COMMITTEE (AMEC) REPORTS, VOL. 1A- SUMMARY OF RANGE INDEPENDENT ENVIRONMENT ACOUSTIC PROPAGATION DATA SETS	Naval Ocean R&D Activity	820901	ADC034017; ND	U
Unavailable	Bartberger, C. L., et al.	THE ACOUSTIC MODEL EVALUATION COMMITTEE (AMEC) REPORTS, VOLUME 2. THE EVALUATION OF	Naval Ocean R&D Activity	820901	ADC034019	U
Unavailable	Deavenport, R., et al.	THE ACOUSTIC MODEL EVALUATION COMMITTEE (AMEC) REPORTS, VOLUME 3. EVALUATION OF THE RAYMODE X PROPAGATION LOSS MODEL. BOOK 2. APPENDICES A-D	Naval Ocean R&D Activity	820901	ADC034022	U
Unavailable	Unavailable	1975-1982 SUMMARY REPORT	Analysis and Technology, Inc.	821217	ADA192591	U
Unavailable	DeChico, D.	ACOUSTIC EVALUATION OF SANDERS ASSOCIATES ACODAC SENSORS	Naval Air Development Center	830301	ADB073873	U
NRL-FR-8695; NRL-8695	Palmer, L. B., et al.	TRANSVERSE HORIZONTAL COHERENCE AND LOW-FREQUENCY ARRAY GAIN LIMITS IN THE DEEP OCEAN	Naval Research Laboratory	830809	ND	U
Unavailable	Unavailable	ENGINEERING SUPPORT FOR ACOUSTIC AND ANALYSIS SYSTEM	Systems Integrated	840101	ADB091112	U
Unavailable	Unavailable	SEAS (SURVEILLANCE ENVIRONMENTAL ACOUSTIC SUPPORT PROGRAM) SUPPORT	Systems Integrated	840229	ADB091119	U